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EDITORIAL

Some Problems in Our Midst

A record-setting deluge at the end of last August in Japan brought about disasters in many parts of the country. In areas heavily hit by rain storms, some 850 mm of rain fell daily for many days. In other parts of the region, e.g., People's Republic of China, Republic of Korea, Indonesia and the Philippines, equally disastrous floods and drought were abnormally heavy this year. These vagaries of Nature were blamed on El Nino at first, and later, on La Nina. As might be expected, agricultural production in these countries were dealt with a heavy blow.

As a net result, rice, which is the staple in much of Asia, has been in short supply for some months now. For example, already Indonesia is negotiating with Japan for the purchase of more than 1.5 million tons of rice. Also, the People's Republic of China is expected to suffer from short supply of rice as a result of heavy rains and the ensuing floods that destroyed acres and acres of the rice crops in many provinces in that country. And for another, the United States was equally hit by El Nino and El Nina to the extent that major cereal crops such as soybean, corn and wheat experienced the lowest princes in recent years.

These disasters notwithstanding, the structure of surplus food production in rich countries and the insufficient food supply in the poor countries has not changed for sometime now. To be sure, the gap between the rich and the poor countries, or the rich and poor families in a given country, seems to continue to widen. Narrowing down the gap continues to challenge the government policy makers as well as agricultural entities.

Developing countries in Asia have, for sometime now, been excerting efforts to catch up with developed countries in terms of industrialization and economic development. And yet, another disaster has struck these countries far greater than the damage of floods and drought, i.e., the economic meltdown and financial crisis from which those countries are still suffering. The pundits estimate that these economic dislocations in the affected countries could take years to recover.

From a wider perspective, the race between population growth and food supply availability in developing and underdeveloped countries seems to continue through the 21st Century. To reconcile this dichotomy is yet another problem because usable natural resources per capita continues to decline year after year in the face of the world's population that has exceeded 6 billion recently. As usual, this calls for a closer cooperation among agricultural scientists, particularly agricultural engineers for the solution of this problem.

The AMA, as before, wishes to help strengthen the global cooperation among agricultural engineers.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
October, 1998

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 29, No. 4, Autumn 1998

Stock Numbers and Use of Animal Traction in Sub-Saharan French-Speaking Africa

by

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Abstract

Since the 1920-30s, animal traction — introduced in the end of the 19th century in sub-Saharan French-speaking Africa for transport purpose — has developed for tillage in Guinea, and planting in Senegal. In 1995 the total number of draught animals was about 2.2 million, including cattle (61%), donkeys (28%) and horses (11%); farm equipment were about 2.5 million including toolbars (multiculteurs) (30%), ploughs (30%), carts (25%), and planters (15%). Four groups of countries have been identified according to agro-ecological conditions (rainfalls, crops, and tse-tse fly infestation), and number of draught animals and farm equipment available. We shall consider only the areas where animal traction prevails.

The first group, situated in arid zones, is characterized by the use of animals for transport and load carrying.

Senegal constitutes the second group. This is an exception since animal traction has spread in the semiarid area (Bassin Arachidier) through mechanized groundnut planting and weeding with horses and donkeys, then through transport with horses both in rural and urban areas. With more than 90% the Bassin Arachidier has the higher equipment rate among farms in French-speaking Africa.

The third group is characterized by the development of cattle traction for tillage of cotton (Mali, Burkina Faso) in the subhumid area and groundnut crops (Niger) in the semiarid area offering favourable conditions for horse and donkey breeding. The most widely used equipment are ploughs, carts, toolbars, and planters. Equipment rates under optimum conditions range from 30% to 75%. Horse and donkey tractions are interesting alternatives that remain inadequately developed.

As regards the fourth group (i.e., Benin, Chad, Central African Republic, North Cameroon, Côte d'Ivoire, Guinea) mainly situated in humid areas, animal traction has been introduced later, and is limited to cultivation (ploughing) and earthing-up with oxen. Here also cotton plays an incenting role, but areas suited to this crop are rather limited. The equipment rate is less than 30% in optimum situations. *Tripanosomiasis*, a major constraint to cattle breeding in humid areas, restrains the extension of animal traction.

Introduction

In 1990, there were about 12 million draught animals in sub-Saharan Africa, i.e., 2 million more than in 1980. Except Ethiopia where animal traction is an ancestral tradition, it appeared at the end of the 19th century to meet military and merchants' transport needs (Bigot, 1985). Then, it will develop with tillage mechanization.

As regards French-speaking Africa, Guinea is the country where government and private firm policies were most efficient to promote animal traction before 1930. Its use for tillage later extended to similar areas in Mali, then to North Nigeria and Ghana. At that time there ap-

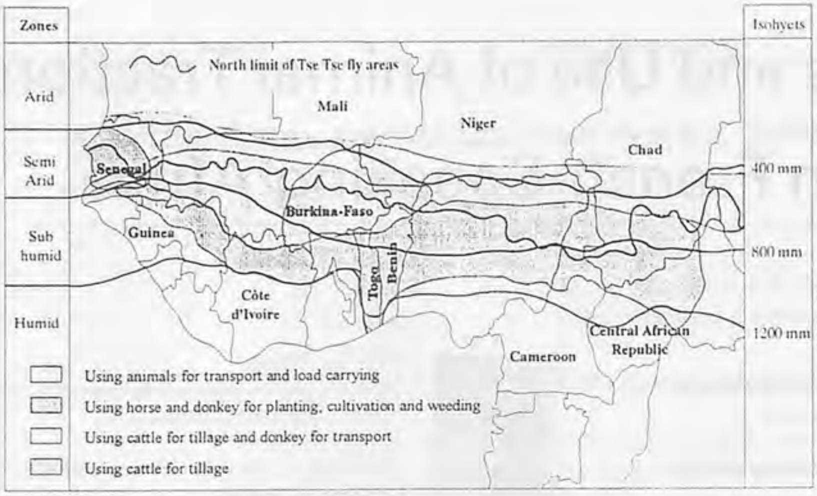

Fig. 1 Main trends in the use of animal traction in sub-saharan french-speaking area.

peared in Senegal an innovation for semi-arid areas i.e., the use of horse-drawn seed planters without previous tillage (Bigot, 1985). The development of animal traction was restrained by equipment supply problems, the harvesting of agricultural products during the 1929 crisis and World War II, and the advent of epidemics.

After WWII, the Great Colonial Powers' policy promoted the development of power mechanization to the prejudice of animal traction. Such situation was often strengthened at the independence time in some countries. This did not result in a significant development of tractor use, except in some particular cases of agroindustrial development.

In the 1950s-60s animal traction made great strides in Senegal and Mali. It appeared in some few places in Gambia, North Cameroon and Niger. It was increasingly popularized in Chad, Burkina Faso and Benin in the 1960s-70s (Bigot 1985).

This paper presents histories of the number of draught animals and farm implements for the following 11 French-speaking countries in Africa: Benin, Burkina Faso, Chad, Central African Republic, Cameroon, Côte d'Ivoire, Guinea, Mali, Niger, Senegal, Togo. Zaire and Congo are not taken into account because draught animals are few in number. Agro-climatic conditions, importance of groundnut and cotton crops, and numbers of draught animals and farm implements make it possible to distinguish four groups of countries (**Fig. 1**).

Draught Animals and Farm Implements: Historical Development

Numbers of Draught Animals per Species

As shown in **Table 1** draught animals have strongly changed in number, mainly in the countries of the semi-arid and sub-humid areas (Burkina Faso, Chad, Mali, Senegal, etc.). **Table 2** shows that there are different bovine species (61%), and more donkeys (28%) and horses (11%) in these areas than in the other sub-Sarahan countries. Dromedary camels and mules are but little used.

Horses and donkeys are generally used singly while cattle are harnessed in pairs. Horses (200-300 kg) and donkeys (120-150 kg) harnessed by breast-strap can pull planters, light hoes and small ploughs on light soil. They are pre-

Table 1. Estimated Number of Draught Animals in Some French-speaking African Countries from 1965 to 1995 (Unit: thousand head)

	1965	1970	1975	1980	1985	1990	1995
Senegal	130	173	265	390	438	495	505
Mali	130	225	300	370	413	460	550
Burkina-faso	4	13	22	40	290	440	580
Niger	1	4	6	16	26	30	35
Chad	24	50	75	108	114	120	126
Cameroon	9	17	25	40	50	73	89
Côte d'Ivoire	0	0	1	26	46	66	90
Guinea	40	50	60	80	100	122	132
Benin	0	3	7	23	30	36	36
Central African Rep.	1	2	2	3	5	7	14
Togo	0	0	1	6	9	11	11
Total	339	535	764	1 202	1 521	1 860	2 168

Source: Abakar Ali Imam 1990; Goe 1990; Bigot and Raymond 1991; Havard 1993; Gueguen 1993; Vall 1996; ENSA 1996; Some 1995; and CIDT 1994.

Table 2. Draught Animal Species Used in French-speaking Africa

Species/Breed		Average Weight (kg) male	female	Localization
Bovines zebus	Sahelian	350-500	250-500	Sahelian Zone (Atlantic to Chad)
	Peul soudanien	—	—	Soudanian Zone (Senegal to Niger)
	Gobra	400	300	M, B, N
	M'bororo	350-500	350-500	N, Ch, Ca, Car
	Goudali	350-500		Car, Ca (Adamaoua)
	Arab	350-400	250-300	Ca (Far North), Ch
Bovines taurines	N'dama	300	250	S, M, G, B, C, Ch, Car
	Baoulé	150	200	West Africa, Car
Equines	Dongolow	250-300	—	West & Central Africa
	Barbe	250-300	—	West & Central Africa
	Arab	250-300	—	West & Central Africa
	Pony	200-250	—	Ca, Ch
Asines Medium type				Afrique occidentale et centrale

Keys: S for Senegal; M for Mali; B for Burkina-Faso; N for Niger; G for Guinea; C for Côte d'Ivoire; Ch for Chad; Be for Benin; To for Togo; Ca for Cameroon; Car for Central African Republic.

Source: IEMVT 1988.

ferred to cattle for transport. A pair of oxen (400-800 kg) harnessed either with a head or a wither yoke can pull 9" and 10" ploughs, ridgers, groundnut lifters, and heavy toolbars.

For the last 25 years, draught animals have increased from 1.5% to 5% of the total number of animals, with some differences between species (11 to 25% for horses; 4 to 18% for donkeys; and 1.5 to 3.5% for cattle).

Numbers of Farm Implements by Type

As shown in **Table 3**, the total number of farm implements has multiplied by more than five times in the last 25 years. The main types of implements are distributed as follows: 30% for multipurpose toolbars and hoes; 30% for ploughs; 25% for carts; and 15% for seed planters.

Other implements, totalizing some thousands units only, must be added to these figures: harrow in Mali and Guinea; ridgers in most of the countries; and groundnut lifters in Senegal. The referred number of toolbars also includes the tools which can be fitted on for cultivation, earthing-up, groundnut lifting, and ploughing. In Senegal, for instance, the Sine toolbar is generally used for weeding and groundnut lifting in the Bassin Arachidier. Cultivation tines and earthing-up bodies can be fitted on plough frames.

In these countries, four models of ploughs, but only two types of cultivation tools, three of toolbars, three of light hoes, one of seed planter, and only three models of carts are prevailing **(Table 4)**. However, many other models and implements are also available. Local artisans produce more or less accurate copies of the implements. Trucks, and horse-, donkey-, and cattle-drawn carts are used for agricultural transport, and specific models for people. Many artisan-

Table 3. Estimated Number of Farm Implements in Some French-speaking African Countries from 1965 to 1995 (Unit: thousand head)

	1965	1970	1975	1980	1985	1990	1995
Senegal	207	384	599	815	828	843	860
Mali	83	107	204	375	425	495	595
Burkina-faso	10	17	57	133	265	425	560
Niger	3	6	13	78	88	98	100
Chad	19	35	59	88	95	110	161
Cameroon	7	12	17	33	39	44	55
Côte d'Ivoire	0	0	5	26	50	70	100
Guinea	15	20	30	45	56	65	71
Benin	0	3	7	18	24	29	31
Central African Rep.	1	2	1	1	2	7	10
Togo	0	1	2	14	19	24	28
Total	345	587	994	1 626	1 891	2 220	2 566

N.B.: Figures include ploughs, multipurpose toolbars, carts, planters.
Source: Le Moigne et al. 1987; Bigot and Raymond 1991; Le Moigne 1985; Havard 1993; Guéguen 1993; Vall 1996; Starkey 1993; ENSA 1996; Some 1995; and CIDT 1994.

Table 4. Manufacturers and Models of Farm Equipment in French-speaking Africa Countries

Equipment	Main Manufacturers	Models-capacity	Licence	Countries
Main Models				
Ploughs	Bourguignon (F)	BP4 - 9"		B, Ch, To, Be
	CNEA, APICOMA	BP4 - 9"	Bourguignon	B
	SISMAR (S)	CFOOP - 10"	Huard-UCF	S
	SMECMA (M)	TM - 10"	Bajac	M
	SIMAT (Ca)	BP4	Bourguignon	Ch
	TROPIC (C)	T34-10"	Huard-UCF	Ca, Ch, CAR
Toolbars	SISMAR, SMECMA	Sine	Mouzon Nolle	S, M, G, N
	SISMAR, ABI	Arara	Arara	S, N, C
	CNEA, ARCOMA (B)	Triangle		B, To, Be
Hoes	SISMAR	Occidentale	Ulysse Fabre	S, M, N
	EBRA (F)	MiniNuba		Ch
	CNEA (B)	Manga		B
Planters	SISMAR, SMECMA	Super Eco	Ulysse Fabre	S, M, B, N
Carts	SISMAR, SMECMA, CNEA, APICOMA, UPROMA	0.5 et 1 T, tyred wheels		S, M, C B To, Be
	TROPIC, SIMAT	1 T, iron wheel		Ch, Ca, CAR
Other models				
Ploughs	RUMPSTATD (Nh)	Sandy III		M
	USOA (G)	Chinoise		G
	SOMATA (G)	NDAMA ACT		G
	TROPIC (C)	T 20 (6"), T27 (8")	Huard-UCF	Ca
	OTMA(I)	10"		G
Toolbars	SISMAR	ARIANA	Mouzon Nolle	S
Hoes	SOMATA	ACT		G
Planters	AUDUREAU-IPEP (F)		Ulysse Fabre	M
Harrows	USOA	Chine		G
	Garnier (F)			M
	SICAM (F)			M, G
Lifters	SISMAR	Firdou	Arara	S

Keys:
S = Sénégal; M = Mali; B = Burkina; N = Niger; G = Guinea; C = Côte d'Ivoire
Ch = Chad; Be = Benin; Ca = Cameroon; Car = Central African Republic
F = France; I = Italy; Nh = Netherlands; To = Togo

ABI	Abidjan Industries, Côte d'Ivoire
CNEA	Centre National d'Equipement Agricole, Burkina-Faso
APICOMA	Atelier Pilote de Construction de Matériel Agricole, Burkina-Faso
ARCOMA	Atelier Régional de Construction de Matériel Agricole, Burkina-Faso
COBEMAG	Coopérative Béninoise de Matériel Agricole, Benin
TROPIC	devenue SCDM: Société Camerounaise de Métallurgie
SMECMA	Société Malienne d'Etudes et de Construction de Matériel Agricole, Mali
SISMAR	Société Industrielle Sahélienne de Mécaniques, de Matériels Agricoles et de Représentations, Senegal
SIMAT	Société Industrielle de Matériels Agricoles du Tchad
SOMATA	Société de Matériel Agricole et de Technologie Appropriée, Guinea
USOA	Usine d'Outillage Agricole, Guinea
UPROMA	Unité de Production de Matériels Agricoles, Togo

made carts are manufactured from scrapped materials, mainly car tyres and axles.

Main Trends in the Use of Animal Energy

The numbers of draught animals and farm implements are distributed according to a range of criteria — rainfalls, cotton and groundnuts crops, and times of animal traction extension — which makes it possible to distinguish four groups of countries (**Fig. 1**) characterized as follows: 1) using animals for transport and load carrying; 2) horse and donkey tractions for planting, cultivation and weeding; 3) cattle traction for tillage and donkey traction for transport; and 4) cattle traction for tillage.

Using Animals for Transport and Load Carrying

In the arid area, agriculture is very limited because of lack of rain fall. So, animals are used only for transport and load carrying.

Using Horse and Donkey for Planting, Cultivation and Weeding

From 1960 to 1980, the number of draught animals increased considerably in the semi-arid area of Senegal because of groundnut cropping. This is an exception since horse traction amounts to 40% while asine and bovine tractions amount to 30% each.

Head yokes are used with both zebu and taurine cattle. They vary in length according to the work to perform: 0.9-1.1 m for ploughing; 1.2-1.8 m for weeding and earthing-up. The equipment fleet is composed of 42% toolbars and hoes; 32% planters; 19% carts; and 7% ploughs. The Super-Eco seeder is used for groundnut, millet, sorghum, maize, and cotton. Multipurpose toolbars are used for weeding and cultivation (Sine hoe, Occidentale hoe), earthing-up (Sine hoe, Arara hoe), and groundnut lifting. (Sine hoe, Occidentale hoe, Arara hoe). Artisans manufacture the lifting body that can be used on toolbars and horse-, donkey-, or cattle-drawn carts fitted with imported tyred wheels. Urban transport is widely developed even for people.

There are three main agroclimatic situations in Senegal: arid, semi-arid, and sub-humid. Although available in the entire country, animal traction is particularly spread in the semi-arid area of the Bassin Arachidier. In this area, asine and equine tractions are specially used for planting, weeding and groundnut lifting. Because light soils prevail, the rainy season is short and groundnut crop only requires minimum tillage, farmer's strategy consists in early planting without tillage. Horse- or donkey-drawn Super-Eco seed planter and a multipurpose toolbar can perfectly meet such requirements. In 1975 horses and donkeys represented 95% of the draught animals available. In this area, more than 90% of the farms are equipped, and 80% own at least one horse, one seed planter, one toolbar, and one groundnut lifter while 50% have a cart each (Harvard 1993). This approximately results in the following ratios: 6 ha of crops by planter; 4 ha by toolbar (for weeding and cultivation); and 3 ha of groundnut crop by lifter. Although not very much used in the area, bovine traction (zebu cattle and cross-bred zebu-taurine cattle) can be found at the frontier between the semi-arid and sub-humid areas in the south of the Bassin Arachidier. In the Sine Saloum region, 37% of the cattle teams rely on cows (Lhoste 1983). There are also some few mixed cow and ox teams, and even single bovine traction when one of the team animals dies.

Using Cattle for Tillage and Donkey for Transport

The country group includes Mali, Burkina and Niger where animal traction has developed but not as rapidly as in the second group. Nevertheless, from 1970 to 1980 animal traction developed markedly because of the stimulus of cotton crop in the sub-humid area (rainfalls from 800 to 1 200 mm) of Mali and Burkina, and groundnut crop in the semi-arid area of Niger. Cattle traction prevails (60 to 70%) before donkey traction (30 to 40%) and horse traction (less than 10%).

The farm equipment fleet is distributed as follows: 29% of ploughs; 27% of toolbars and hoes; 13% of seed planters; and 13% of carts. Over a 25-year period, these countries have extended their use of draught animals from ploughing to planting, weeding, and transport. Oxen are used with ploughs, toolbars, cultivators, planters and carts; donkeys with carts; and horses with trucks.

Horses and donkeys are typically suited for transport which confirms a 1 ratio between the number of carts and the number of these animals.; Bovines harnessed with a wither yoke are used for ploughing and earthing-up on cereal, cotton and groundnut crops; the ratio between the number of pairs of oxen and the number of ploughs is 1.1. Mechanized weeding and planting are not as widespread as in Senegal. Ox traction is widely used for tillage of paddy fields in Mali and Niger.

In the centre of the south Mali region (main cotton growing area in the country), animal traction is most used but land saturation is almost completed. Cotton crop covers 25 to 50% of the farm area, including more than 75% concerned with animal — mainly cattle — traction (Guéguen 1993). Draught animals are principally used for ploughing, and also for cultivation-weeding, and earthing-up on cotton but to a lower extent, and more rarely for planting.

In 1989, 33% of the farmers own an animal team in the cotton growing area of Burkina Faso (Schwartz 1991; Faure 1994). Ploughing with draught cattle harnessed to 9" ploughs is widely applied. Ploughs may also be fitted with earthing-up bodies. Furrowing, cultivation-weeding are generally performed with Houes Manga, Triangle and Sine, while planting with the Super Eco seed planter is rather unusual (Garnier 1995).

Using Cattle for Tillage

This group includes Benin, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Guinea and Togo. The development of animal traction is slower in these countries, mainly because their climatic conditions (limits of sub-humid and humid areas) are badly suited to easily mechanized crops such as cereals, cotton, and groundnut. On the other hand, as tripanosiomasis occurs in the region horse and donkey traction is not very used (less than 10%). Animal traction is also available in cotton growing areas and rice growing flood plains.

The equipment fleet is composed of 61% of ploughs (1 per pair of oxen); 25% of multipurpose toolbars and hoes; 12% of carts; and 3% of seed planters. Special uses of animal traction fit the division into sub-humid and humid areas, or semi-arid ones for some countries (Cameroon, Chad) as shown through the following three examples: Côte d'Ivoire, North Cameroon, and Guinea.

Côte d'Ivoire — In the north, in sub-humid area, vegetation is rather scattered, land clearing relatively easy, and there is a good many cross-bred bovines of the zebu-taurine type. Maize is the prevailing food crop, well-suited to the use of animal traction, as also is cotton (ridge cultivation). Draught cattle has increased from about a hundred pairs in 1970 to more than 65 000 in 1990. In the west, situated in savanna humid area, natural vegetation is thicker. N'Dama bovines are fewer. Rainfed rice, the prevailing food crop, does not easily adapt to animal draught technologies. Draught oxen have increased from about a hundred head in the 70's to 10 000 at the present time, mainly in the northern part of the area. In the centre, a humid forest-savanna interfacing area, shrub vegetation is thicker, there are many stumps, and less cattle than in the west. Yam is the main food crop (ridge cultivation). Draught animals are limited to some several hundred head despite the formal transfer of animals from the west. On the other hand, animal traction competes with hand-tool technologies (on fallow lands) as these are less expensive in areas where population is scarce.

Cameroon — Draught animals can be found in semi-arid and sub-humid areas in the north. Oxen are mainly used for ploughing and, to a lesser extent, for cotton earthing-up and weeding (20% of the ploughs are fitted with earthing-up and weeding bodies). Five percent of bovine traction relies on draught cows. Horses and donkeys are increasingly used in areas with low rainfall (600 mm/year) where direct planting is often preferred to ploughing (Dugué et al., 1994; Vall 1992 et 1996). From 1990 to 1995 the number of horses increased by 300%, and that of donkeys by 75%. In 1995 only 6% of the farmers owning animal teams used a cart (Vall 1996).

Guinea — In the subhumid areas (upper and middle Guinea) cattle traction is widely used, for ploughing (ploughs) in cotton growing areas, and also for paddy tillage in flooded plains (secondly tillage with harrows). Animal traction is also widespread on the Fouta Djallon plateaux for ploughing *fonio*. Carts are but seldom used (less than 3% of the equipment), and only in the drier areas bordering Senegal and Mali where horses and donkeys can be found. Attempts are being made to introduce animal traction in the seaside and forest areas (in mangrove and lowland paddy fields, respectively) but difficulties are many, especially disease and theft risks to animals, and arduous working conditions in mangrove and lowland paddy fields.

Conclusions

Analyzing the draught animal and equipment numbers makes it possible to define, in terms of spread/extension and use of animal traction, four groups of countries. As regards the progression line of animal traction, it starts from the semi-arid areas towards the sub-humid, then to humid ones, following the development of agriculture and stock rearing in the countries. In their present situation, these groups are faced with specific issues of animal traction development and changes.

The first group, situated in arid zones, is characterized by the use of animals for transport and load carrying.

The second group, consisting of the Senegalese Bassin Arachidier, is an exception. It is characterized by the use of draught donkeys and oxen for groundnut planting, weeding and lifting, and also for urban and rural transport. Its equipment rate among farms amounts to 90%, that is the highest rate in French-speaking Africa. In such a context, priorities should aim at maintaining the equipment level, improving and diversifying the use of animal traction.

The third group, mainly situated in sub-humid zones, is marked by the development of cattle traction for tillage in cotton growing areas (Mali, Burkina), and groundnut growing ones (Niger). Nevertheless, local conditions are well-suited to donkey and horse rearing. Animal traction has first extended through the use of ploughs, then planters and toolbars. Transport mainly relies on donkeys. Under optimum conditions, 25 to 40% of the farms are equipped in Burkina and Niger, and 75% in South Mali. Accordingly, primary importance should be accorded to the improvement and diversification of animal traction uses in areas with high equipment rate among farms, and in the others to an increase in such rate through tillage and transport.

As for the fourth group (Benin, Chad, Central African Republic, North Cameroon, Côte d'Ivoire and Guinea) mainly located in humid zones, animal traction was introduced later. It is limited to cultivation (ploughing) and earthing up with oxen. There also, cotton plays a driving role, but areas suited to this crop are locally limited. Less than 30% of the farms own animal-drawn implements under optimum conditions. Tripanosomiasis, a major constraint to cattle rearing in humid zones, restrains the extension of animal traction. Priorities in animal traction programmes should aim at its development on a sustainable basis. Actions on stock rearing, and also those concerning farmers' sensitivation and training are most important.

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Draft Animal Power and Its Research in Ethiopia

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Abstract

Animal traction in Ethiopia has been used since the third millennium B.C. Its use is confined to land preparation and seed covering using the traditional implement 'maresha' pulled mainly by a pair of oxen under a ridged neck yoke. Even though research to replace the 'maresha' and the multi-purpose use of animal power have been carried at different places of the country, its adoption were with little success. To feed the increasing population of the country and curtail the alarming land degradation, the traditional agricultural system has to change to a more productive one. The role of animal traction in this intensification process could be enormous. The present paper discusses the status of draft animal power and animal-drawn implements in Ethiopia.

Introduction

Draft animal power has been an integral part of the agricultural system in most parts of Ethiopia for thousands of years. Available evidence indicates that cattle were first used for ploughing in the latter part of the third millennium B.C. (Goe and Astatke, 1989). To this date the traditional cattle economy of the country has mainly been directed towards supplying draft oxen.

Ethiopia has the largest livestock population in Africa with approximately 38 million head of cattle of which 9 to 10 million oxen are used for draft purposes. Paired Zebu oxen are the main animals used for work, primarily for tillage and threshing. In some areas where oxen are in short supply, horses, mules and donkeys are either hitched with the same species or in mixed pairs. Sometimes oxen are paired with equines or barren cows for ploughing. All the three species of equines are mainly used for transport and for threshing in most parts of the country. In the lower highlands (below 1500 m asl) and the drier regions camels are exclusively used for pack and transport. Several attempts have been made to develop implements to intensify and diversify animal power in the country mainly for improved primary and secondary tillage operations. Research have been conducted to develop precise and acceptable planters and weeders. Efforts have also been made to use single animals and cows for traction and introduce alternative uses of animal power for transport, crop processing, land shaping and water lifting.

The objective of this paper is to review the past and present animal traction work in Ethiopia and to discuss the prospect of animal draft power in the future.

Traditional Tillage Implement

Even though it is not certain when during the start of the agricultural period the use of animal tillage implements began, it has been conjectured that Ethiopians inhabiting the northern cereal growing highland areas of the country were introduced to the ard between 1000 and 400 B.C. by Semitic speaking invaders from South Arabia (Goe, 1987). A more recent hypothesis, based on available archaeological evidence, suggests that the use of the "ard" or Ethiopian plow may have been developed previous to the Semitic invasion by the Cushitic-speaking peoples from an ancient region called Nubia in north-eastern Sudan (Goe, 1987). Regardless of who introduced the ard "maresha", the traditional animal-drawn implement, its acceptance and utilization have contributed towards developing crop-livestock integration currently existing in the country.

There are certain areas in the highlands where hoe cultivation is still practiced. But, in general, cultivations are carried out by oxen pulling the traditional implement (the maresha) which consists of a metal point or tine, fastened to a wooden arm (Gebresenbet, 1995), to the pole which is in turn, fastened to a wooden neck yoke as shown in **Fig. 1**.

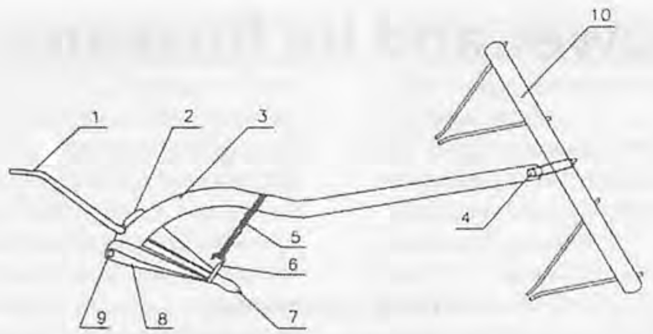

Fig. 1 A sketch of a traditional Ethiopian plough (ard) (3) and wooden neck yoke (10).

At each side of the metal point are two wooden wings or moldboard which push the soil aside. The traditional implement is light, ranging from 17-26 kg with the yoke (Goe, 1987) and makes it possible to be transported together to and from the field over different terrains by one person. Except for the metal tine, which the farmer has to buy from the blacksmith, the rest is home made. It is versatile and can be used on all soil types. Depending on the crop and soil types, two to five cultivations are required by the maresha before a field is ready for planting. The seed covering of all crops except 'Eragrostis tef' is also made by the same traditional implement.

Each cultivation pass with the maresha is made perpendicular to the previous one so as to turn over the topsoil. The depth of the first ploughing ranges from 5 to 8 cm while with the last pass a depth up to 20 cm could be attained. The time required for land preparation also varies from 100 h/ha to 150 h/ha for Vertisols and light soils, respectively (Astatke and Matthews, 1982). The maresha has the advantage of being handled by a pair of indigenous oxen each weighing not more than 300 kg. The power developed by a local zebu oxen pulling the maresha ranges between 0.50 and 0.90 kW (Astatke and Matthews, 1982). The power developed is dependent on soil type, soil moisture, soil compaction status, depth of ploughing and the pulling power of the animals.

A serious disadvantage of the maresha is that it is a cultivating implement rather than a present-day, ordinary plough which means that the soil is not inverted and is of very little use in turning stubble and weeds. Weeding is the major activity in the agricultural calendar making it one of the most serious bottle-necks in agricultural production. The other problem using the maresha occurs during seed covering. The depth of seed coverage varies by seeds which are not covered at all to the maximum depth which the maresha tine penetrates. This might be the one reason why farmers tend to double or sometimes triple the seed rates recommended by research institutes, as germination rates will be low otherwise.

Research on Tillage Equipment for Replacement of Maresha

Attempts by the Italians in 1940 to introduce a steel mouldboard plough at the smallholder level were unsuccessful because of its weight, required complicated adjustments and a higher power requirements than that of the maresha, specially on soils with high clay contents (Goe and Astatke, 1989). In the 1950s, FAO reportedly developed a plough but no large scale production and use occurred.

Between 1955 and 1965 a substantial instances of testing of implements using oxen, horses and mules were tried at Alemaya University of Agriculture in Eastern Ethiopia and Jimma Agricultural Technical School in Southern Ethiopia. Implements tested included steel mouldboard ploughs, a single-disc plough, spike tooth and disc harrows and several different types of planters and cultivators (Canaday, 1959). Much of the work was carried out at the experiment station level, rather than on-farm. Reports tend to stress that the improved implements were suitable for accomplishing required tasks but that lack of knowledge on the part of the farmer, lack of parts and weak animals caused the technology to be unacceptable (Canaday, 1959). There seems to have been little recognition of the fact that problems regarding farmers adoption were largely due to equipment being inappropriate for the power source, complicated in design and operation, difficult to repair and too costly.

A major effort was initiated in 1968 by the implement research section of the Chilallo Agricultural Development Unit (CADU; name later changed to Arsi Rural Development Unit, ARDU) in that part of the country to develop tillage implements and carts. Later investigations were carried out to include threshers and water-lifting devices. Several trials were conducted to evaluate both locally manufactured and imported ploughs and tool-bars from the USA, India and countries from Europe (CADU, 1969, 1970, 1971). The studies demonstrated that the use of the mouldboard ploughs and harrows could reduce cultivation time by up to half of that required for the maresha but yield was not significantly increased.

The development of a suitable mouldboard plough as a replacement for the maresha continued to be difficult up through 1980, with the major obstacles being cost, weight, and difficulties getting repairs made at the artisan level. Past attempts to modify the maresha have included the development of the Jimma plough in the wooden soles and share were substituted with flat iron strips and a vertical knife, the Vita plough, the complete ard head of the maresha was replaced with the metal mouldboard assembly, and the ARDU plough, a modified version of the Vita plough (Berhane, 1979).

On-farm trials demonstrated that the Jimma plough provided better tillage than the maresha on sandier soils but showed little advantage when used on fallow plots or those soils having high clay contents. Tests with the Vita plough prototype indicated that design changes in the mouldboard assembly and the angle of the handle were necessary to improve its tillage performance. Even though these modifications were incorporated into the ARDU plough it was rejected by both farmers and extension workers because it was too heavy to be transported to and from the field, the metal frame which was attached to the beam to support the mouldboard assembly did not provide adequate stability and it had a higher draft power requirement than the maresha (ARDU, 1980). There has been little adoption of these implements in the country.

In 1976 the Agricultural Engineering Department of the Institute of Agricultural Research (IAR) began to develop and test farm tools and equipment appropriate for the agricultural conditions in Ethiopia. One study evaluated an implement package consisting of mouldboard plough, spike tooth harrow, imported tool-bar and hand operated planter for better crop production (Berhane, 1979). With these implements the 2.5 ha normally cultivated by a pair of oxen could be increased to 6-8 ha but weeding and harvesting were major bottle-necks. However, the implement package by its own did not have a significant impact on grain yield increases. Adoption of the technology was also dependent on the untested assumption that several families would have to pull their resources to purchase and use the implements, an important socio-economic aspect which has to be throughly investigated.

The International Livestock Centre for Africa (ILCA) has been conducting research on tillage implements in relation to their power requirements, cultivation and weeding times and crop yields on different soil types. Details of this work can be found in the reports of Astatke and Matthews (1982, 1983, 1984). Principal findings showed that the use of steel mouldboard plough can reduce cultivation time by at least half that required for the maresha cultivation. This level of reduction agrees with figures obtained from similar trials reported by CADU (CADU, 1970) and others. In another study, the use of a mouldboard plough or spring tine cultivator for initial tillage, followed by secondary tillage and using zigzag harrow for seed covering did not significantly result in better weed control than the traditional system which employs the maresha from three to five operations. No significant differences were observed in the performance among the three implements.

The Farm Implement Division of the Ethiopian Ministry of Agriculture (MOA) imported about 30 wheeled tool carriers which were distributed for evaluation in farmer testing centres in different parts of the country. The implements were found to require more draft power than the indigenous pair of oxen could produce and durability of parts and maintenance were a major problem.

The Relief and Rehabilitation Commission (RRC) has tried to integrate the use of draft animals and mechanization by employing tractors for primary cultivation and oxen secondary tillage and seed covering in some resettlement areas in the western part of the country (RRC, 1981). Animal-drawn mouldboard ploughs were imported from Kenya, India, UK and the Netherlands but were rejected by farmers due to their weight and high draft requirement (Aberru Ketema, 1987).

Research on Land Shaping Equipment

The International Crops Research Institute for Semi-Arid Tropics (ICRISAT) developed systems of broad-bed and furrow (BBF) cultivation method using wheeled tool-carrier (Bansal and Srivastava, 1981; ICRISAT, 1983). Although experimental results were encouraging (Ryan and von Oppen, 1983) farmer adoption was minimal (Starkey, 1988). In Ethiopia, the International Livestock Centre for Africa (ILCA) with the collaboration of national and international institutions started developing low cost land-shaping implement based on the maresha (**Fig. 2**) in 1986 after briefly evaluating the wheeled tool-carrier. Astatke and Kelemu (1993) described the development of the broad-bed maker (BBM) for the formation of BBFs.

Initially two mareshas were permanently joined to construct the BBM. This resulted with an implement that was effective but difficult to transport because of its

Fig. 2 Broadbed maker developed based on the conventional ard (Ethiopian plough).

weight. This led to developing another version of the BBM which is in use today. The top ends of the maresha beams are tied together and connected to the yoke in the traditional method. For maintaining the distance of 1.2 m between the maresha tips, a crossbeam was tied between the two poles of the maresha at around a meter from the lower edges of the poles. Simple metal wings attached on each inner flat wings facilitate the pushing of the soil inside forming a 1.2 m BBF from mid-furrow to mid-furrow. The chain attached at the end of the metal wings not only shape the beds evenly but also covers the pre-sown seeds. The power developed pulling the BBM by a pair of local zebu oxen averages 0.62 kW which is the range of the power required for the maresha. With the use of this implement the excess water is drained off through the furrows leading to a better crop environment, thus higher grain and straw yields than the traditional practices for most crops. The Ministry of Agriculture and some non-governmental organizations are now extending this technology with its package (Asamenew et al. 1993).

The ILCA, in cooperation with several local organizations, has been investigating the use of animal drawn scoops for excavating new ponds or desilting old ones. The aim has been mainly to supplement dry season water supplies for humans and livestock but the water could also be used for supplementary irrigation as well as starting fish farming.

The basic scoop design employed in the initial trials was similar to the traditional Dutch mouldbaert and the British eighteen century 'levelling box' (Brandford, 1976). These European implements were designed to be drawn by large animals, and so ILCA developed a smaller version with a capacity of 0.15 m^3 that could be pulled by a pair of Ethiopian zebu oxen. Initial testing of the technology began in 1983, with the excavation of a 7000 m^3 pond on ILCA's research station in Debre Berhan, 120 km northeast of Addis Ababa (Astatke, 1984).

Simple Implements for Pond Construction

The maresha is first used to break-up the soil surface where the pond is to be excavated. The loosened material is removed with the scoop to dumping site at one end of the pond. The maresha is then used again to break-up the subsoil which in turn is removed by the scoop. This pattern of tillage and scooping continues until the pond is completed. The total amount of time spent for scooping depends on the size of the excavation to be made, the condition of the animals, the friability and moisture content of the soil. At Debre Berhan, approximately 10 hours of tillage was required for moving 100 m^3 of soil (Astatke, et al. 1986).

The average draft power developed by a pair of local zebu oxen pulling a full scoop was 0.92 kW which falls within the upper range of power needed for the first pass with the maresha (Astatke, 1984). Subsequently, the MOA modified the scoop to reduce power requirements. The new models are about 15% smaller than the first prototype and have two metal skids on the bottom to reduce friction. The scoops are robust and if the wooden handles break they can easily be repaired by the armers themselves.

Using animal-drawn scoops, two ponds of 9500 m^3 and 8700 m^3 capacity were constructed in 1985 by two Peasant Associations (**Figs. 3a** and **b**). Farmers worked about 75 days and employed 1 350 ox-pair days on each pond. On average, the oxen worked about 6 hours a day, with 3 pairs breaking up the ground and 14 pairs engaged in excavation with scoops. Net excavation rates (including both ploughing and scooping) were about 6.8 m^3 of per oxen per day (Anderson and Astatke, 1985). A pair of oxen used for desilting ponds were able to excavate 13 m^3 of silt per 5 h working day (Haile Selassie and Cossins, 1985).

Fig. 3(a) Pond construction process by peasant associations using draft animal power.

Fig. 3(b) A pond dug by farmers.

Use of Carts and Sledges

The tasks performed by animals are traditionally limited to tillage, threshing, packing and human transport. It was not until 1936-1941, during the Italian occupation, that the use of horses, mules and donkey for carting became established within and around the larger cities and towns and in coffee growing areas (Vitali and Bartozolozzi, 1939). Carts brought into Ethiopia by the Italians were constructed by the artisans using local materials and imported components such as axles, wheels and bearings. During the 30 years following independence, the use of animal-drawn wheeled transport changed very little within the country (Huffnagel, 1961). This situation occurred mainly due to the costly imported components.

In 1969 the CADU began developing prototypes of two-wheeled carts for single horses or donkeys and paired oxen. The axles were forged in the country while the iron-rimmed wooden wheels with metal bushings were imported. The prototype carts were loaned by the extension personnel to interested individuals in Arsi province for testing and evaluation, and also to determine farmer demand (CADU, 1969). Some fabrications of ox carts using iron wheels and axle assemblies from discarded vehicles was also carried out by CADU, but these offered limited possibilities due to lack of old equipment and spare parts (Kline et al. 1969).

The ARDU presently manufactures steel-wheeled carts that could be pulled by horses, donkeys and oxen based on the design similar to that introduced by CADU. Most of these carts are found within Arsi province, although there is limited use elsewhere in the country. Strong extension support and credit facilities have made farmers in Arsi Province generally more receptive to the use of carts than in other parts of the country. In recent years there has been an increase in demand for donkey and ox carts where roads have been constructed and local artisans have been trained to make repairs.

Although the use of carts in Ethiopia is not widespread, two wheel pneumatic-tired carriages (called "garees"), usually pulled by a single horse, are heavily relied upon to transport people and goods within and on the outskirts of many urban areas. Heavy duty two wheel carts fabricated from wheel and axle assemblies of discarded vehicles are also used on a small scale. In and around towns in Southern Shoa Province, within the vicinity of Lake Ziway, firewood and water drums are commonly transported on locally constructed wooden carts that have small casted spooked wheels and which are pulled by one donkey. Occasionally, paired oxen are employed to pull these carts on dirt roads in the same area.

Sledges have been in use in Arsi Province and some pockets of the country for nearly 50 years to transport crops from fields to threshing areas (Kaline et al. 1969). They are locally constructed from wood and are pulled by a team of oxen.

Use of Cows for Traction

The use of local cows for work is traditionally limited to few areas of the country. Even then farmers use only barren cows paired with oxen when there is an acute shortage of male animals. The local zebu cows are small, not weighing more than 250 kg, and producing less than 400 kg of milk per lactation period.

An on-station study to determine the effects of using pairs of crossbred dairy cows (50% Boran-50% Friesian) for draft (**Fig. 4**) showed that at low levels of work and with proper feeding and management, work had no significant effect on milk production and reproductive performance (Agyemang et al. 1985). A follow up collaborating study between IAR and ILCA is presently being carried out to determine nutritional needs for work, milk and reproduction by working crossbred cows at rates and periods similar to those encountered on-farm. Results over a period of three years show that diet was the main factor which affected body weight, days in milk, milk production, number of conceptions and number of calvings of crossbred cows, whether working or not (Gemeda et al. 1994; Zerbini and Gemeda, 1994). Recently, on-farm verification of using crossbred cows for work has started as a continuation of the station's positive findings by IAR and ILCA.

Fig. 4 Crossbred dairy cows used for traction.

Agricultural Status in the Country

At present, the population of Ethiopia is 52 million with growth rates of 3% annually (World Bank, 1993). Well over 80% of the population is directly engaged in agriculture and of these the majority are in the Highlands above 1 500 m asl. Providing more food for the increasing population still remains a problem in the country. The major reason for the shortage of food is the adoption of traditional production systems with low or no production inputs for improvement of yields.

The Ethiopian Highlands are also losing alarming amounts of soils (estimated as one billion tons) annually. This loss, associated with nutrient losses, reflect directly on the declining agricultural production and bio-diversity. The type of land use determines the degree of degradation and cultivation practices on soil losses which destabilise the ecological equilibrium. About 80% of the annual soil losses occur from crop-lands during the rainy season. Nutrient imbalance is further accentuated by forest clearing, removal of crop residue from cultivated lands and low chemical fertilizer or organic manure use. These have become common with increasing human and livestock populations.

Even at present, the main source of power for agriculture (97%) in the country is a pair of oxen. The use of oxen in the traditional farming system in Ethiopia is limited to seed bed preparation and threshing. Gryseel et al. (1984) has reported that farmers in Ethiopia work their oxen for some 450 pair hours. This is equivalent to 2 months per year although the work potential of draft cattle can be 8-10 months as is estimated in India. Possible reasons for this low use might include feed inadequacy over the working periods and non-use of oxen for transport and other tasks during the long non-cultivation period.

Future Role of Animal Traction

The Ethiopian agricultural lands are fast degrading under the combined effects of continuous cropping and over-grazing. If sustainable agricultural production is to be attained in the country, a more efficient and productive animal traction use should be developed and extended to the farming community at large.

As this review points out, a substantial amount of research on various aspects have been carried out over the past years. There is urgent need to draw together the results of these research, recognizing past mistakes, and reorient future work so that the full potential of animal traction can be realized. Farmers must be included from the outset in evaluating draft animal technologies since they are the ultimate users. Well planned on-station studies must be followed up by extensive on-farm verification trials to properly evaluate a new technololgy policies that promote agricultural intensification should be implemented to achieve the full technological benefits.

With agricultural land constraint in the country, agricultural intensification using animal power will not only raise the productivity but would also sustain the resource base. A good example of using animal power for boosting crop production would be the construction of broadbeds and furrows as a land management system on Vertisols or on lands with vertic properties. The broadbeds and furrows will allow planting of crops at the beginning of the main rains without any adverse effects of water-logging on these potential agricultural areas not fully utilized traditionally. This means that there can be vairous options to utilize the entire growing period for growing higher grain and straw yielding crop varieties. The early planting of short duration crops could allow an early harvest making a second crop possible on the residual moisture (Astatke et al. 1991). If water can be conserved in ponds or reservoirs, a sequential crop would be feasible in the same through minimal supplementary irrigation at planting time to secure germination. The same furrows of the broadbed system that evacuated excess water during the rainy season would be used as furrows for irrigation.

The main reason Ethiopian farmers keep cattle is for draft purposes. The back-up stock required for supporting the work oxen can be considerable. As farms are fragmented and land preparations occur concurrently, farmers are short of work oxen. Feed supplies are low and further herd growth will increase herbage extraction from grazing lands to the detriment of the environment. The pressure on land and feed will make it necessary for herd reduction. The use of cows for multiple tasks will be an important avenue for achieving this, as it has happened in similar situations in other countries (Matthewman, 1987; Sowe and Reed, 1990). Increased feed productivity from intensified land use can be targeted to meet feed requirements of the selected high performing livestock.

With the appropriate research and development, the prospect of making traditional agriculture responsive to the changing situations to increase productivity should be possible. The role of animal traction in the intensification of agricultural production of this country seems to be enormous.

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An Investigation on the Side Effects of the Aerial Spray Cypermethrin on the Pilot, Mechanic and Pennant Carriers

by
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Abstract

The side effects of aerial spray, Cypermethrin, which was used to control sunn-pest (*Eurygaster integriceps* Put.) on the airplane's pilots, mechanics and pennant carriers were investigated. The levels of serum cholinesterase, serum protein electrophorese, SGOT, SGPT were examined, including routine blood tests were conducted on the same 26 individuals. In addition, the amount of the aerial spray deposited in the pilot's cabinet was determined using a tracer material.

After each flight large chemical deposits were found both on the pilots' clothes and also in the pilots' cabinet. However, the biochemical analyses revealed no significant changes in the pilots blood.

Introduction

The sunn-pest is a very harmful agricultural pest in Turkey and the control against it is made by the government. Two of fields 1 539 568 ha and 47 020 ha (or a total of 1 586 588 ha) were scanned by plane and by ground machine, respectively, in 1992 (Anonymous, 1993).

In this application 45 plane flights sprayed a total of 34 475 kg Fenitrothion 3% dust; 44 101 ℓ of Cypermethrin 25 EC; 685 653 ℓ Cypermethrin 2,5 ULV and 18 154 ℓ Fenitrothion 95 ULV and 73 383 kg-ℓ pesticide were used. The use of ULV has been very popular in the last years. In spite of its being a very effective pesticide, it was not appreciated by the pilots because it can stay for a long time in the weather and affects directly the pilots' breathing and skin.

The cleaning and maintenance of the pilot's cabin is rather difficult when ULV is used because it is not soluble in water but is soluble in gasoline and alcohol.

On the other hand, conventional pesticides are preferred because of their short life time in the air and they can be cleaned easily with water and on the plane breasts and do not cause any congestion and pollution problems.

In the present study, the effects of pesticide residues has been examined on pilots, mechanics and pennant carriers. In addition, a base study was executed in the city of Adıyaman and Diyarbakır by the partnerships of Plant Protection Research Institute of Adana and the University of Çukurova.

Cypermethrin was used more than the other pesticides during the experiment in 1991. Only two planes were tested for the determination of pesticide contamination on clothes and pilots' cabins since trace material was inadequate for testing.

Materials and Method

Studies with Trace Material

In this study 26 pilots, mechanics and pennant carriers were tested who were controlling sunn-pest in Adıyaman and Diyarbakır areas. The types of planes and their characteristics are Piper Pawne C (AU 5000) microner owned by Martı Co., and Piper Pawne D (AU5000) owned by the Türkerler Co.

In the application of the pesticides, the pilots and pennant carriers wore special clothes (cotton like screen type of material). A small aspirator was attached in the cabinet in order to determine the effective dosage of the pesticide taken by breathing during the flight.

The pesticide in the cabin air was kept on the filter paper which was placed on the outer part of aspirator. After the flight, these papers and special clothes were put in poly-

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ethylene bags and labelled for analysis with the rest of material in the laboratory. For the experiment, pesticide "Arrivo" which includes the Cypermethrin 2,5 (ULV) effective was used as applied for sunn-pest control (1. and 3. periods of nymph) with the dosage of 180 mℓ/da. Stardust trace material was in this pesticide with a 0.5% dosage.

Individually, the pesticides were analyzed fluorometrically which were measured in μg level on clothes and filter papers.

Biochemical Studies

At the beginning of the sunn-pest pesticide test, on May 4, 1991, 10 mℓ of blood was drawn from 26 individuals using vacuum type sterile injectors and the blood was transfered into sodium heparin container tube and carried into the laboratory in an ice box. The ages of the test people, their first and last dates of exposure to pesticides and their previous medical problems which was related to pesticides were recorded.

The blood test was repeated on May 19, 1991, just after the sunn-pest control. Serum cholinesterase, serum protein electrophoresis, SGOT, SGPT and routine blood tests were examined in these samples.

Results and Discussion

Studies with Trace Materials

The speed of cabin air which pass from the aspirator is 2 m/s. The inner diameter of aspirator pipe is 90 mm. Hence, the total air which passes through aspirator and crashes on filter paper is 763 ℓ/min.

A pilot breathes 8 ℓ air depending on 0.5 ℓ air per breath and 16 times of breath for every minute (Grandjean, 1975). The ratio of air taken by pilots breathing the air which dashed onto filter paper from aspirator is 8/763 or 1/95.

Table 1. Pesticide Contents Taken by Way of Breathing in Pilots Cabin (Pilot without mask)

Pilot who does spraying	Taken Pesticides Content (μg/min)	Adsorbed Pesticide Content (μg/cm²)
Pilot I	0.057	0.429
Pilot II	0.051	0.378

Table 2. Pesticide Contents Taken Through the Skin*

Pilot who does spraying	Taken Pesticides Content (μg/min)	Adsorbed Pesticide Content (μg/cm²)
Plane I	16.98	0.577
Plane II	17.31	0.566
Plane II - Pennant carrier	17.82	0.594

* Pilots do not use cap, glasses and mask. Skin surface exposed pesticide is supposed to 150 cm².

Table 3. Maximum and Minimum Values and Their Mean Deviation, Related to Biochemical Tests

Parameter	Control	Before Spraying	After Spraying
Total Bilirubin (mg/dℓ)	Rank 0.3-1.1 (0.6±0.2)	0.2-0.8 (0.4±0.2)	0.3-0.8 (0.5-0.2)
SGPT (U/mℓ)	Rank 7-38 (19±10)	7-107 (38±32)	7-147 (40±34)
SGOT (U/mℓ)	Rank 10-36 (21±8)	7-98 (29±23)	8-138 (33±26)
Alkalen Fosfataz (U/ℓ)	Rank 46.8-95.8 (75.6±15)	50.4-38.2 (160.2±132.3)	72.7-651.6 (184.6±142.3)

Biochemical Studies

In the present study, the function tests of total bilirubin, SGOT, SGPT, and alkaline phosphates values in the liver were performed using the Technicon 6/60 and 12/60 automation systems. The results obtained from these tests are presented in **Table 3**.

There are two enzymes which are acceptable as indicator enzymes for liver functions. These are special transaminase enzymes of alanine aminotransaminase (ALT and generally known as glutamic pyruvic transaminase GPT) and Aspartate aminotransferase (generally, glutamic oxalatic acid transaminase GOT).

For the blood samples before the pesticide exposure 38-32 and 29-23 U/mℓ were determined, respectively, for GPT and GOT. The 40-34 and 33-26 U/mℓ concentration values were obtained for the same enzymes after the pesticide exposures. These results show that there were no significant differences between before and after pesticide exposures.

Alkaline phosphates enzyme is very important indicator for ascertaining the problems of the liver. With the above information, it has not been observed important variations of livers functions with the available tests during, before and after pesticide exposures.

Table 4. Cholinesterase Values in Blood Examples (V/mℓ)

Sample Number	Before Spraying	After Spraying
1	4.9	3.5
2	5.8	5.2
3	7.6	6.9
4	6.9	6.07
5	7.3	6.9
6	8.16	7.89
7	10.06	9.06
8	12.3	11.03
9	10.9	9.8
10	10.3	9.6

Results of Cholinesterase

The variations in cholinesterase level depend on pesticide as shown in **Table 4**.

Table 4 shows that choline sterase did not show any decreasing trend after the exposure to pesticide. In this study of trace material, it has been observed that the pilots were able to snatch very hazardous effect of pesticides, especially when they do not use glass, mask, gloves and headgear. In contrast, if they could use these attachments, hazardous effect of pesticides can be minimized. Perhaps, mask is not very important, but especially the uses of glass, headgear and gloves must be required. Generally, the pennant-carriers who are from the local public are not experts on pesticide use by planes. They do not use special protectors. In reality, they take more materials than a pilot per day. Fortunately, their work periods are several hours to several days, because they are temporarily employed by the owners of fields.

On the other hand, more important problems are observed with the workers who carry pesticides to planes. They work without taking any precaution and also their hands and clothes are in touch with pesticides all day.

Franklin et al. (1981), have studied pesticides residues, e.g., Guthion ULV and their extra absorption from epidermis for workers who worked for British Colombia. The workers were required to wear cotton-shirts, trousers, short-sleeve shirts, eye glass protection, breathing mask, high boot and hat. In addition, 8 people were required to wear water-proof clothes. A good correlation was obtained between alkaline phosphate and effective materials in urine which are tested after 48 hours exposure which showed that the effective material could pass easily from patch parts of clothes to epidermis. In addition to the work habits of workers, clothes used and personal resistance, environmental conditions such as wind, and temperature influence the transfer of pesticides to the workers' skin. Generally, the water-proof and light clothes are more protective than heavy ones.

Gupta et al. (1980), have executed blood, urine tests and Cholinesterase enzyme tests on 7 workers and 5 mechanics who were affected by ULV to pesticide with Malathion which was used against mosquitos in the field on 7 were pesticide carriers. All workers were exposed to pesticides since they did not put on special clothes, glasses, mask, etc. The amount of Cholinesterase showed a decreasing trend in blood and urine of the carriers.

The absorption of greater amounts of Malathion was directly related to the handling of materials by workers not wearing protective clothes. The workers in the field were less affected during pesticide exposure even when they were in contact with the pesticide droplets. Mechanics did not show a significant difference before and after exposures.

It has also been shown that in ULV applications, even when it contains less toxic material, the temperature and humidity of the medium and protein defficiency of the person influence the absorption of the material into the body. Even so, the workers must use protectors for their health.

The wide spectrum synthetic pyrethroid materials have less toxic effects on people. Cypermethrin LD_{50} Acut Oral 251-4123 mg/kg equal to dermal > 2 400 mg/kg also have less toxic effects. The dosage for people is 0.05 mg/kg (Anonymous, 1987). During pesticide spraying the airplane pilots work 10 hours and stay 45-55 min in the air. If **Tables 1** and **2** are closely examined, the pilots are gradually affected by the pesticides during exposure and this may create toxic effect on their health.

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Testing and Evaluation of Cultivator

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Abstract

Shovel is a critical component of the cultivator. Wear and tear of the shovel is very fast. This is mostly because of improper material and hardness.

Four different makes of shovels (samples) were selected from the market for the wear test. Hard surfacing was done with durite 3-B electrode coating and heat treatment. These shovels were tested in the field and results were taken at 20, 40, 60, 80 and 100 hours use. Loss in weight (g) and breakage (%) of the shovels was also recorded after 100 hours use. Hard facing of the shovels by electrode coating was best treatment as compared to other as minimum wear (19%) was measured on hard faced shovels and maximum wear (49%) was measured on without heat treated.

Based on the comparative analysis, Sample "A" was the best suited due to its good performance against wear and hard surfacing by electrode coating was the best treatment for hard surfacing.

Introduction

The cultivator (a.k.a tine tiller) is used for seed bed preparation, weeding, pasture renovation and mixing of fertilizer in the soil (Anonymous 1991). Hussain et al. (1983) reported that the cultivator is the most popular and widely used implement among farmers in Punjab and N.W.F.P. On the other hand, disc harrow and moldboard plow are the most popular in Sindh and Baluchistan. The reason of popularity of these implements in the region as pointed out by ex-member of a world plowing organization is that at the time of agricultural mechanization in Pakistan, the farmers of different regions adopted the same tractor-drawn implement which was introduced initially by the tractor manufacturers. He stated that in Punjab and N.W.F.P., the cultivator was initially introduced while in Sindh and Baluchistan disc harrow and moldboard plows were introduced. Nowadays each tractor owner-farmer has a cultivator. Cultivators are available in 7, 9, 11, and 13 tines but 11 tines cultivator is very common.

The shovel is bolted on the tines. Shovels of cultivators wear out very fast because of improper material and hardness of these components. These components have to be replaced often with new ones resulting in great inconvenience and loss of money and time on the part of the farmer. Keeping this problem in view, wear studies were conducted on reversible shovels used in cultivators. The shovels used are, in general, made of mild steel (MS) resulting in high degree of wear.

Mian Channu is main centre of agricultural machinery production. The cultivators are manufactured by most of the manufacturers. Agricultural machinery manufacturers at Mian Channu purchase shovels from the local market which are supplied by shovel manufacturers through their dealer in Mian Channu. The major production centre of shovel are Lahore, Gujranwala and Sadiqabad. Agricultural machinery manufacturers have also complained about the quality of shovel. Therefore, it was felt necessary to test the quality of locally available shovels in the market and suggest recommendations for their improvement.

Objectives of the Study

This study was conducted with the following specific objectives;

(a) To evaluate the technical performance of shovels (weight, hardness, breakage, material composition and price); and
(b) To test the shovels of different material composition with heat treating, without any treatment and surface electrode coating in the field.

Review of Literature

The Pakistan Standard Institute (PSI) specifies the material and hardness for shovels (Anonymous 1986) which recommends using steel with carbon content ranging between 0.55 and 0.88%, i.e., SAE 1080 or EN 45 and Brinell hardness ranging between 350 and 450 which is equal to Rockwell hardness about 39 to 48 HRC for shovel.

Raval and Kaushal 1990 reported on hard surfacing of the cultivator shovel by using electrodes: Ultimum N112, Cromcarb N6006, Modi 600, Lomet 303 and Lomet 304. Specific geometrical pattern based on critical wear locations was selected. For single-layer hard-surfacing, this was based on economical and technical consideration. A special soil-bin wear test was conducted on these shovels under controlled test conditions. From an economic point of view, Lomet 303 was found to be the best hard-surfacing electrode.

Singh et al. 1993 conducted wear test on five different samples of shovels, i.e., mild steel, spring steel, high carbon steel, coated mild steel and heat treated mild steel on a rotary soil bin for 100 h each. Loss in weight for each shovel due to wear was recorded. Three types of soil, i.e., light, medium and heavy soil were used for the wear tests. Based on a comparative analysis, the heat treated mild steel shovel was best suited keeping in view the life of shovels as compared to the normal mild steel shovels.

Materials and Method

For evaluating the technical performance of shovels, three sets of each make were purchased from the local market and analyzed at the testing laboratory of the Centre for Agricultural Machinery Industries (CAMI), Mian Channu. The material chemical composition was measured at the Central Testing Laboratory, Lahore.

The dimension of the shovels was measured with the help of a measuring tape and vernier caliper. The weight was measured with a Digital Electronic Balance having at least count 0.01 g and hardness was measured with the help of Rockwell Hardness Tester.

Wear studies were conducted in the field of Mian Channu. Four makes (Samples A, B, C and D) of shovels were tested with different treatments (without treatment, heat treatment and hard facing by electrodes). These shovels were bolted to the tines to analyze the effect of treatment and material (make) on the wear of the shovels in a farmer's field.

Heat treatment of the shovel was done at the electrical hardening furnace and electrical annealing furnace. The hardening of the shovels was done in an electric hardening furnace at a temperature of 870°C in which heatup time was 45 min and soaking time of 20 min and then quenching was done in oil. After hardening, the tempering of shovel was done in an electric annealing furnace at a temperature of 500°C in which heatup and soaking time were 15 min and one hour, respectively, and then cooling was done at room temperature.

The hard facing of the shovels was done by coating them with Durite 3-B electrodes. Every shovel was weighed after 20, 40, 60, 80 and 100 hours' use and loss of weight was also measured after field testing.

Results and Discussion

Each sample has different weight which shows that shovel manufacturers are not following any standard. Chemical composition of different materials of shovels are shown in **Table 1**. The hardness, weight, loss in weight, wear, breakage and price of shovel without any treatment, heat treatment and hard facing are presented in **Table 2**. The results of shovel test after 100 hours use of the each cultivator shovel is shown in **Table 2**. The comparative results are presented in **Figs. 1, 2** and **3**.

Table 2 shows that the shovel without any treatment has less hardness as compared to heat treated ones compared with those that have heat treated shovel hard face. The hardness of shovels increases with heat treatment and hard facing. The

Table 1. Chemical Composition of Different Materials of Shovels (Unit: percent)

Shovel Sample	Carbon	Silicon	Manganese	Phosphorus	Sulphur
Sample A	0.65	0.26	0.94	0.03	0.01
Sample B	0.53	0.18	0.86	0.02	0.03
Sample C	0.40	0.17	0.74	0.02	0.02
Sample D	0.42	0.17	0.84	0.01	0.02

Table 2. Performance of Shovels

Treatment	Sample	Hard-ness HRC	Dimension L x W x H (mm)	Total Weight	Loss in weight	Wear (%)	Break-age (%)	Price (Rs.)
Without any treatment	Sample A	33	303 x 71 x 6.5	765	205	27	6	18
	Sample B	21	295 x 61 x 6.2	688	248	36	5	16
	Sample C	22	296 x 61 x 6.1	650	299	46	7	15
	Sample D	18	303 x 60 x 6	640	314	49	4	15
Heat treated	Sample A	39	301 x 70 x 6.45	755	154	20.4	11	23
	Sample B	35	293 x 60 x 6.16	668	196	29.3	10.5	21
	Sample C	27	294 x 59 x 6.03	637	240	37.7	8.4	20
	Sample D	34	301 x 58 x 5.94	625	181	29.0	9	20
Hard faced	Sample A	52	303 x 71 x 8.4	789	150	19	7.5	27
	Sample B	48	295 x 61 x 8.15	704	198	28.4	7.6	24
	Sample C	45	296 x 61 x 8.03	674	154	22.8	5.1	23
	Sample D	47	303 x 60 x 7.95	660	178	27.1	5.2	23

maximum hardness of 52 HRC was achieved in sample A. The wear of the shovel decreases with heat treatment and hard facing. Minimum wear of 19% was found in the hard-faced shovel of sample A and maximum wear of 49% was found in shovel without any treatment in sample D.

The breakage of shovel increases with hard facing and heat treatment. Maximum breakage of 11% was found in heat treated shovel of sample A and minimum breakage of 4% was in shovel of without any heat treatment of sample D.

The wear, weight vs. time relationship of the shovels without any treatment, heat treatment and hard facing are shown in **Figs. 4**, **5** and **6**, respectively. These graphs indicate that wear increases with time in all the treatments and in all the samples. The wear was maximum for shovels without any treatment, medium for heat treatment shovel and minimum for hard faced shovel.

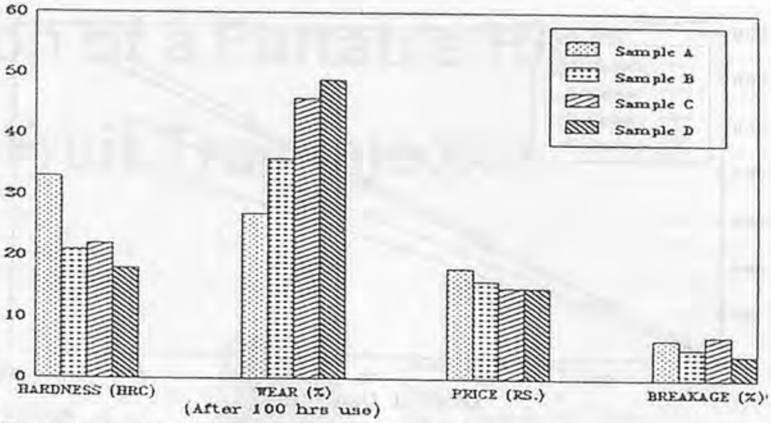

Fig. 1 Comparative performance of shovels (without treatment).

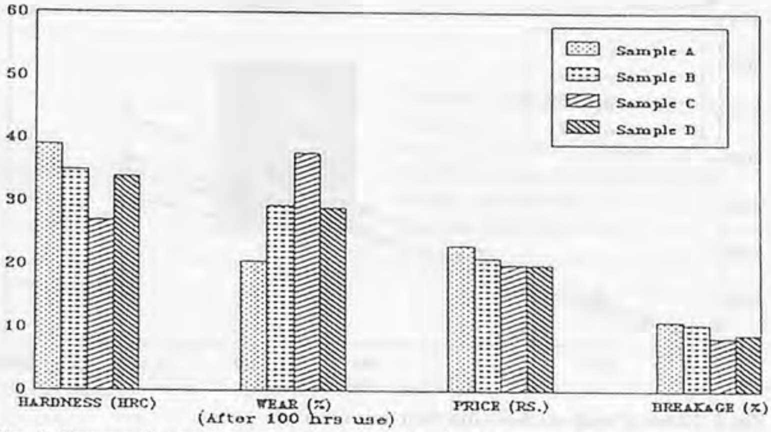

Fig. 2 Comparative performance of shovels (after heat treatment).

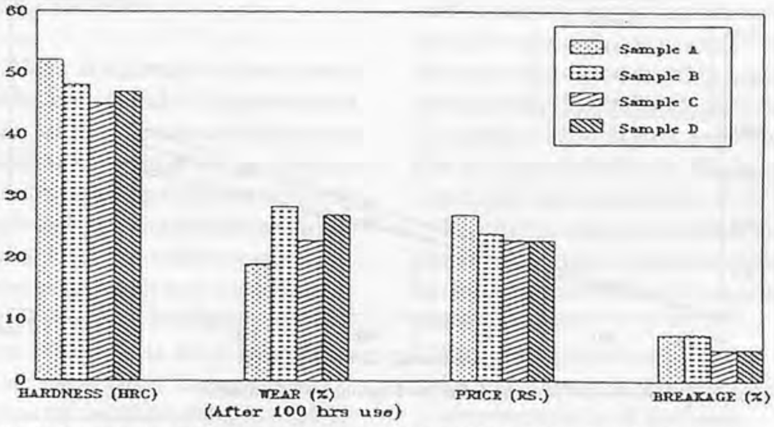

Fig. 3 Comparative performance of shovels (after hard facing by electrodes).

Conclusion and Recommendation

1. The locally-made shovels are not of good quality as per requirement of the Pakistan Standard Institution.
2. Manufacturers are not using proper raw materials for manufacturing shovels.
3. Heat treatment and hard facing increase the hardness of shovels and reduce their wear but increase the breakage due to increased brittleness.
4. It is recommended that shovel manufacturers properly heat-treat the shovels to improve quality.
5. Hard facing reduces the wear. However, it is expensive. Therefore, a cheaper way but effective of hard facing should be explored.

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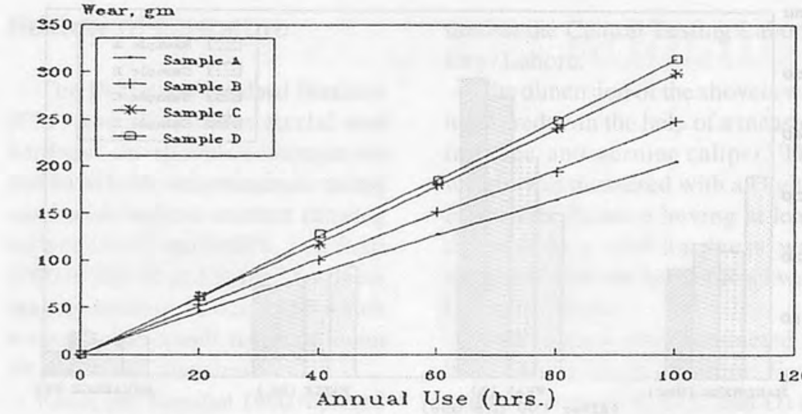

Fig. 4 Extent of wear vs. time (without treatment).

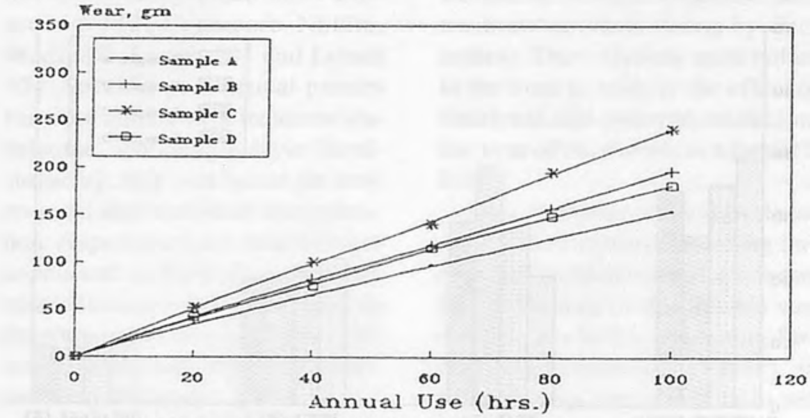

Fig. 5 Extent of wear vs. time (after heat treatment).

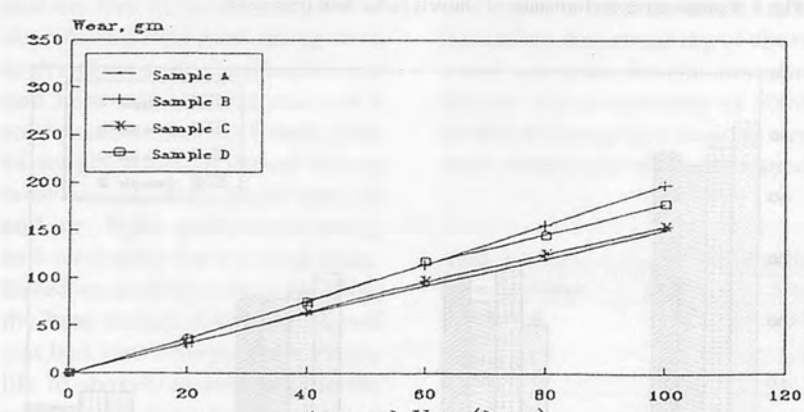

Fig. 6 Extent of wear vs. time (after hard facing by electrodes).

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Application of a Portable High Pressure Fruit Tree Injector


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Abstract

In view of the problems in the traditional method of preventing and controlling fruit tree diseases and pests, a new kind of equipment and technique is to inject liquid chemicals into the trunk with the use of a portable high pressure fruit tree injector developed at the Southwest Agricultural University. In this paper, the structure and principle of using the injector, the application and effect are presented. The study results shows that the injector can fully meet injecting technology demands of even large trunks, and the problems such as pollution, low effect and high consumption can be solved fairly in the use of the new technique.

Introduction

When fruit trees or forest trees suffer the inroad of diseases and pests or deficiency elements, the traditional method for preventing and controlling them is spraying chemicals or microfertilizer on the leaf surface, in which some problems exist, such as seriously polluting the environment, wasting chemicals, being slow result and short valid time, being often affected by weather changes such as wind, rain etc., hence missing the timeliness of prevention and losing in production.

As was tested, under given pressure, liquid could be rapidly conveyed to the crown and other parts of a tree through the ducts and ducted cells in the tree. According to the test, we assumed that liquid chemicals were injected into the trunk so as to prevent and control tree diseases and pests, and to replenish trace elements. In comparison with the traditional method, it is quite evident that the problems can be solved fairly in this way, especially for urban trees.

In order to meet the demands of injecting liquid chemicals, the injector must satisfy the requirements as below:

1. Have enough pressure;
2. Strong corrosion resistance and wear resistance of the parts;
3. Good sealing property and slight damage to the trunk;
4. Reliability; and
5. Small bulk, light mass and convenient operation.

In accordance with the above requirements, we developed a portable high-pressure fruit tree injector, and carried out a lot of applied tests.

Structure and Principle

The features of the portable high pressure fruit tree injector are: 1) miniature high pressure pump; 2) low-pressure tube; 3) storage box; 4) manometer; 5) high pressure flexible tube; 6) injecting needle; 7) operating lever; and 8) pedestal (**Fig. 1**).

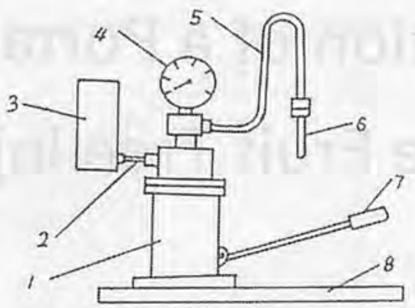

Fig. 1 Sketch of the pressure pump.

Fig. 1 shows the whole structure of the injector. It consists of a storage box, miniature high pressure pump, low pressure tube and high pressure flexible tube, injecting needle, manometer, operating lever and pedestal. The total mass is less than 7 kg, while the liquid flowing rate is not less than 100 mℓ/min, and the injecting pressure may reach over 25MPa. It can successfully inject liquid chemicals into any substantial-sized tree trunk.

While the injector operates, the lever is controlled by manpower. Liquid chemicals is loaded into the pump from the storage box through the low pressure tube. The pump pushes the liquid towards the needle through the high pressure tube, and then into a tree trunk. The high pressure liquid is conveyed to all of the ducts through their compact holes and cell gaps, and by means of the high pressure of the liquid and the transpiring pull force of tree body, the liquid flows rapidly upward to the crown of the tree.

It was determined that only one needle is required to transport liquid chemicals upwards along all of the ducts of trunk's cross section. A test was taken on a loquat tree of 30 cm diameter so as to gauge upward velocity and crosswise velocity. Before testing, two holes on the trunk were drilled, one at the site of 1 m high above the injecting hole, and another at the other side of the trunk just at the same height as the injecting hole (1 m from the ground). About 40 seconds after injecting liquid in, the liquid began to flow out of the hole at the other side. About 80 seconds later, the liquid flowed out of the upward hole. Moreover, while injecting 500 mℓ water solution of tracting element P^{32} into an old teak tree of 4 m high to measure the time of the solution's reaching the crown leaves, it was indicated that about 40 minutes later there was the tracing element in the leaves on a fine day or about 3 hours later on a cloudy day. In fact, the time of the tracing element's reaching the leaves is sooner than that of being shown by the instrument because the instrument shows nothing until the tracing element in the leaves reaches some density.

The needle is threaded with special non-standard thread. Before injecting, a small hole on the trunk is drilled so as to screw the needle in. The diameter of the hole is slightly less than the inside diameter of the thread, and the depth of drilling is about 1 cm deeper than that of screwing in. Thus part of the injected liquid can directly flow upwards along the cut ducts so that the resistance is weakened but the velocity is quickened.

The sealing principle of the needle is shown in **Fig. 2**. The needle having been screwed in, high pressure exists on the interface between the thread and the hole, and the liquid must pass a long winding path to seep, which results in good sealing. When the liquid is injected into the trunk, the high pressure of the liquid acts on the front face of the needle, and this experts great pressure between the left side surface of the thread and the hole.

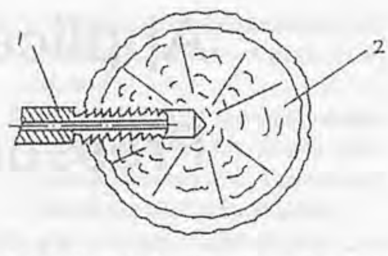

Fig. 2 Sketch of cross-section of a tree trunk being bored by a screw.

Therefore, the sealing is automatically strengthened with an increase of the injection pressure.

Generally, chemicals have strong corrosiveness, and some hard impurities are inevitably mixed up in them. Thereby, the corrosion resistant material, which can resist the corrosion of PH4-8, was adopted and case-hardened.

The injector is operated by manpower (hand's pressing down or foot's stepping on). Its whole mass is less than 7 kg, so transfer is very convenient. It can accomplish a injecting process in one to three minutes while 100 to 300 mℓ chemicals is demanded for each tree. If the injector driven by power, the increase of the flow rate may cause liquid to flow too fast, flow resistance to increase too large and the pressure to rise too high, and lastly the trunk to crack. Besides, it is calculated that the power is about 0.0083 kW, and the operating force of pressing down is only 55 N by manpower, so an ordinary labour can be well qualified.

Application and Effect

Between 1990 and 1994, insecticides were injected into fruit trees and urban ornamental trees many a time by the injector. As a result, the rate of killing the pests such as aphids, mites, scales, orange puppy, red and black citrus leafminer (*Throssoryssa citri*), and citrus blossom midge (*Contarinia citri*) reached more than 95%, while the natural enemies of the pests were not killed. Injecting antibiotics and germicides can cure a lot of the diseases of fruit trees.

If a fruit tree grows many years on the same land, physiological diseases will appear frequently for lack of trace elements in the soil, which results in the reduction of the yield and the drop in fruit quality. It can get the perfect effect of curing the deficiency elements that trace-element fertilizer is injected into the trunk.

For example, in 1988 at Beibei, Chongqing, $FeSO_4 \cdot 7H_2O$ solution was injected into orange trees and redish mandarin trees to cure the disease of Fe deficiency and leaf-yellowing. Half a month later, the leaves distinctly turned green, and all of them deep green a month later. Up to these days the leaves haven't lost the green color.

Another example: in 1993 at Bazhong city, Sichuan, the mixed solution by $ZnSO_4 \cdot 7H_2O$ and $FeSO_4 \cdot 7H_2O$ was injected into a wide range of the diseased trees with Fe and Zn deficiency. The result was encouraging.

Since 1989, during the crucial period of plant growing stage, we have separately injected nutritious liquid, rare-earth element, growth adjusting agents and sugary materials into various sorts of fruit trees, the effects of which were better than those of leaf-surface spraying at the sides of promoting the differentiation of blossoms and buds and the growth of fruits, improving the quality and raising the yield and so on.

At the moment, owing to the beneficial results of society and the economy, the injector has been spreading over wide areas in China (more than 10 provinces and municipalities).

Conclusions

1. A new kind of equipment for plant protection, the portable high pressure fruit tree injector has the advantages of high injecting pressure (over 25MPa), strong corrosion resistance and wear resistance of the main parts, good sealing and conveniently transferring (under 7 kg of the total mass). It can suit the needs of all kinds of substantial trunks and can be used in different relief conditions.

2. Adopting the injecting method to prevent and control the diseases and pests of trees can not only solve the problem of environment pollution that is long standing but unsolvable by the spraying means, but also isn't affected by any natural condition. Therefore, prevention and control may be conducted in good time, and it has quicker result, better effect and lower cost.

3. Owing to the non-pollution of environment, it has more special significance that the injector is applied to the scenic trees in urban gardens and landscapes for tourists.

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Simulation of an Alternative Floor Heat Source in Broiler Production Using Solar Energy

by
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Abstract

Even under tropical and subtropical climate conditions, raising chicks within the thermal comfort zone is a challenge. The supplementary heat source normally used by producers in order to maintain 29-31°C in the building is obtained through burning GLP, associated with electrical thermal resistance. In some periods of the years 80 bottles of 13 kg of gas is needed for raising the flock's first three weeks. While this main need of energy is during the night, during daytime there is an exta heat supply coming from the solar radiation, which has not been used by the producers. The main objective of this research was to develop an alternative solar heat source to supply the heat need for raising chicks, using the thermal inertia applied concept. The principle is based upon the use of a heated floor, with a thickness of 0.30 m, and a full scale tank of heated water below the floor. A solar collector heats the water during daytime and, because of the concrete floor inertia, the heat migrates to the inside environment during the night. The simulated projected system using 15 solar collectors of 3 m², with the slope of 35 degrees was able to heat to a comfort zone, a flock housing of 90 m², during the coldest winter months.

Introduction

Broiler production at the first three weeks needs an extra source of heat for maintaining their thermoneutral body temperature. On the other hand, the tropical and subtropical climates provide specially during the intermediate seasons, a large temperature amplitude varying up to 15°C in less than 10 hours. Growing chicks within the thermal comfort zone is then a challenge. The supplementary heat source normally used by producers in order to maintain 29-31°C in the building is obtained through burning GLP bottled gas, associated with electric thermal heaters, as well as wood burning furnaces. During winter conditions the main cost for the producer is related to GLP and electrical consumption bills, in the first three weeks for growing a flock.

The average solar radiation load in the Southeastern area of Brazil, in the Tropic of Capricorn, is approximately of 600 W/m² on a flat surface. Within the broiler housing the main need for energy is during the night, while during daytime there is an extra heat supply coming from the solar radiation that has not been used by the poultry producers.

The objective of this research was to develop an alternative solar heat source to supply the heat need for raising chicks, using the thermal inertia concept. The testing of the designed heat system was through a simulation using two different softwares. The first simulates the building environmental thermal conditions, which is called Casamo-Clim. The second calculates the solar heating system for a given climate condition, called F-Chart.

Literature Review

Broiler production is highly affected by temperature differences, specially during the first three weeks of growing. **Table 1** shows the thermal comfort temperature as cited in Fabricio (1994). According to Malavazzi (1992), the proposed density under tropical conditions are 30 to 36 chicks per square meter in the first three weeks, going up to 10-12 birds per square meters during

Table 1. Ideal Temperatures According to the Birds Growing Period

Age (day)	Temperature (°C)
1-3	31
4-7	28
8-14	26
15-21	24
22-30	23
31 - slaughter	21

Table 2. Broiler Sensible Heat Production

Weight (kg)	Temperature (°C)	Sensible heat (W/kg)
0.1	29	12.0
0.7	30	6.0
1.1	30	4.0
1.6	19	5.7
2.0	19	4.8

the growing period up to 42-45 days.

The total heat balance is mainly affected by the metabolic heat coming from the birds themselves. This heat lost to the environment is dissipated as sensible heat. **Table 2** shows the data of sensible energy dissipation, according to Hellickson and Walker (1983).

The process of heat transfer occurring between inside and outside the building environment is considered in transient regime because of the changing conditions along the same day. According to Frota and Schiffer (1988), in the transient regime the thermal inertia in building materials influences the heat exchange timing process, for being a time- and temperature-dependent phenomenon.

Due to a large quantity of solar radiation available in tropical countries, much research has been done during the 70s, but mainly for urban areas application. The solar water heating process is well known and largely utilized in urban use. However, an alternative solution for heating small chicks housing is rarely reported in literature and certainly not being used in Brazil.

The software CASAMO-CLIM was developed by the Centre D'Energetique (1989) and simulates the inside housing thermal environment, considering the heat exchange in variable regime. Data entry consists of the outside climate conditions, housing geometry and building materials thermal characteristics, and all sources of heat load. The model was validated, and used by Stangenhaus (1992) in reduced scale models, being found a difference of less than 3%, in the prediction, compared to the simulated values.

The model that calculates the overall design of heat collector system, based upon data on solar radiation amount and angle of incidence, water temperature and flow on the collector inlet, volume of water to be heated and the collector thermal efficiency characteristics, is called F-CHART (FAU-UFRJ, 1990). The results obtained using this software are the solar collector area and the prediction of the conventional supplementary heat source amount.

Methodology

The simulation test for solar heated floor in broiler housing used the geographic and climatic data, as shown in **Table 3**, is based upon the winter data collected at the Federal Rural University of Rio de Janeiro, Brazil.

The flock density, as well as the length of time of heating the birds adopted for the simulation process was the usual utilized normally by producers, as 30 chicks per square meter, at the third week. As the temperature requirement for the birds changes through the weeks, it was necessary for the calculations to establish a design temperature of 30°C. Even though some authors cite different temperature requirements, in average conditions this was a suitable choice, specially for the second week. Supplementary thermal comfort requirement can be provided by either artificial or natural processes.

The building material characteristics adopted for the model simulation were: walls in perfurated ceramic brick (commonly used in Brazil) covered with vermiculite-cement plaster; roof on wood isolated with mineral wool; double windows in two opposite walls; and a floor designed to be heated by hot water coming from the collector.

The system of solar heated floor was developed based upon the thermal inertia concept. It consists of determining the ideal conditions to design the floor through an optimization process, based on the optimal collector dimensions and efficiency. Some of the ideal parameters found and boundary conditions such as water flow thickness

Table 3. Climatic Data on Latitude of 22°47'S and Longitude of 43°40'W

Month	Radiation (kJ/m^2.day)	Temperature (°C)		Relative humidity (%)		Wind speed (m/s)	
		Average max.	Average min.	max.	min.		
Jan.	20758	30.5	21.8	85.9	46.8	2.5	N, SE
Feb.	21374	32.3	22.0	87.8	51.4	2.3	N, SE
Mar.	19094	31.1	21.2	90.1	53.1	2.2	SE, S
Apr.	15279	29.0	19.1	91.0	53.1	2.1	S, SE
May	13064	27.7	17.2	87.3	49.1	2.3	NE, S
Jun.	12189	26.7	15.7	87.6	47.9	2.4	NE, N
Jul.	12690	26.5	15.0	87.6	47.8	2.4	NE, S
Aug.	14081	27.5	16.0	90.3	47.1	2.7	S, N
Sep.	14455	27.5	17.0	89.9	50.7	2.8	S, SE
Oct.	17465	28.0	18.0	90.6	51.4	2.7	S, SE
Nov.	19466	28.8	19.5	91.1	52.6	2.7	S, SE
Dec.	18992	30.2	20.8	89.6	51.1	2.5	SE, S

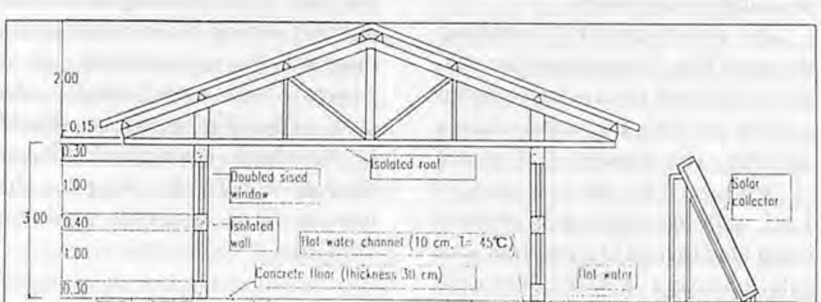

Fig. 1 Side cut of the simulated designed building.

underneath the floor of 10 cm and temperature of 45°C, the concrete floor thickness of 30 cm and the inside temperature of 30°C were fixed initially. The housing thermal balance calculation as well as the acess of the thermal material's properties data was done using the software CASAMO-CLIM, considering the heat exchange in transient regimen. The proposed and simulated design is shown in **Fig. 1**.

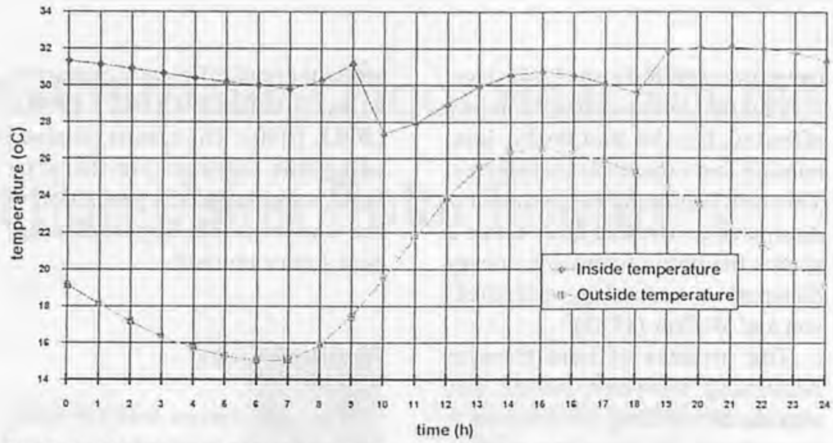

Fig. 2 Inside and outside dry bulb air temperature daily variation.

Results and Discussion

The results obtained by simulation regarding the dry bulb temperature within the building and outside, are shown in **Fig. 2**.

In **Fig. 2** it is evident that the effect of the thermal floor heat system maintains the inside dry bulb temperature approximately constant, around 30°C, while the outside dry bulb temperature varies from 15°C to 26°C. As the thermal amplitude is a decreasing production factor, alleviating this effect may represent a benefit for the producer.

The point in graph related to 9:00 am shows that, if the system was maintained with closed windows, the tendency of the inside dry bulb temperature will continue to increase reaching values above the thermoneutral zone. This problem can be avoided by managing correctly the timing for opening and use the natural ventilation.

The environmental condition shown in **Fig. 2** reproduces the situation designed for a solar collector system heating the water during daytime. The simulated projected system used 15 solar collectors of 3 m^2, with the slope of 35 degrees being able to heat to a comfort zone a flock housing of 90 m^2, during the coldest winter months.

For the coldest days of July, the solar heating system can supply up to 78% of the bird heat needs. Other source of conventional heat must be used to reach the thermoneutral requirement. If electrical resistance is to be used, a 643 W thermal resistance operating for 6 hours daily must be added to the water tank.

Conclusion

The project can be used for producers in rural zones in order to substitute the non-renewable energy source commonly used for poultry production (GLP). A solar heated floor, with a thickness of 0.30 m, and a full scale tank of heated water below the floor may be the solution. The simulated projected system using 15 solar collectors of 3 m^2 with the slope of 35 degrees was able to heat to a comfort zone, a flock housing of 90 m^2 during the coldest winter months.

Further studies must be pursued in order to test the best thickness of the floor for optimizing its thermal inertia. Testing other construction materials for reducing the use of concrete and, consequently, the costs of building the floor, should be considered. The determination of the cost - benefit ratio other than the use of GLP analysis must be verified.

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Dynamic Balancing of a Rigid Multi-mass Thresher Rotor and Vibration Control

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Abstract

A simple method was presented and used for in-place dynamic balancing of a rigid multi-mass thresher rotor. Reciprocating inertia forces that arise from operation of the sieve unit were partially balanced and the extent of the partial balance that reduces the vibration levels to a minimum was determined. Studies on the vibrational response under the laboratory and actual field conditions were conducted to determine the effectiveness of balancing for vibration control at the source. Depending upon the conditions and frequency of operation, vibration levels can be reduced by 60% to 90%. The level of residual imbalance was achieved that is well below the acceptable limit of 160 g-mm/kg (160×10^{-6} N-m/N) body weight of the rotor.

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Introduction

Farm mechanization has played a vital role in bringing about and sustaining the erstwhile Green Revolution in India. Threshers have played a special role in post-harvest operations of wheat crop for which the production has increased many fold over the last 2, 3 decades. Many types and makes of wheat threshers have been developed indigenously over the years. Although the functional designs of almost all the threshers are quite satisfactory, still there is a need for improvement in their dynamic performance for a smooth functioning and prolonged fatigue life (Bansal, 1985). It is one of the aims of this paper to present a simple method for vibration control which can be easily employed by small scale manufacturers of farm machinery.

Wheat threshers can be categorized into chaff-cutter (Toka) type, Beater type and spike-tooth type threshers. More recently, a high capacity Haramba Thresher was also introduced which is basically a toka-type thresher as it combines into it good features of other threshers. From the dynamicist's point of view, all threshers can be broadly divided into two categories. One, the threshers with narrow single mass/disc rotors which can be balanced statically. Two, the threshers with long/multi-mass rotors which have to be balanced dynamically to counter the imbalance moments.

The rotors of a simple toka type thresher can be considered to be single disc type and their static balancing is quite effective in reducing their imbalance to acceptable limit (Bansal and Gandhi, 1996). All the other types of threshers have their threshing drum, winnowing fan, driving pulley etc. mounted on a single shaft. These multi-mass rotors being long cannot be balanced statically (Bansal, et al. 1992). Torsional vibrations of such a multi-mass thresher rotor have been studied by Rao and others (1985). Critical speed of these rotors is generally quite above their operating speed. A rotor is said to be rigid if its operating speed is far below the first critical speed which corresponds to the first natural mode of the shaft vibrating in flexure (Muster, 1961). A rotor is said to be flexible if it operates near or above its first critical speed (Darlow et al. 1981).

In the present study, a method somewhat similar to those of Thearle et al. (1934) and Van de Vegte et al. (1978) was employed to balance the multi-mass thresher rotor dynamically.

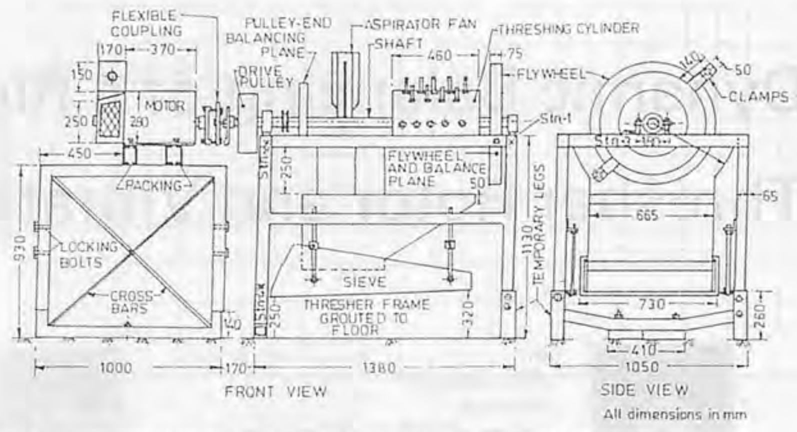

Fig. 1 Experimental set up for dynamic balancing of multi-mass thresher rotor.

Experimental Set-up

Sophisticated balancing machines are very costly and are not available for balancing thresher rotors which are usually of large size. Thus, to determine the extent of imbalance and to balance the rotating and reciprocating masses without the use of a balancing machine, the main frame of the thresher supporting the thresher rotor was temporarily modified. The aim is to study the dynamic response of the rotor in-place without disturbing the actual positions of the bearings. **Figure 1** shows the front and side views of the experimental set up used for conducting the dynamic performance studies on a spike-tooth type thresher under laboratory conditions. A rigid adjustable mild steel frame supported the variable speed D.C. motor used for running the thresher rotor through a flexible coupling. The upper cover of the thresher and its transport wheels were removed. Temporary legs were attached to fix the frame direct to the heavy concrete floor with the help of grouted foundation bolts. The flywheel and a specially made circular ring mounted on the shaft between the driving pulley and the aspirator fan were used as two planes for mounting the balance weights. There is a provision of mounting the clamps to hold the trial masses which can slide along the periphery of the flywheel and the circular ring. The angular position of the trial masses can be read off the circular scale in degrees. Vibration levels were measured at the ends of the horizontal members supporting the bearings of the rotor shaft (Station-1 and Station-2), on the member directly supporting the rotor bearings near the flywheel (Station-3), on the vertical member where the sieve driving mechanism is attached (Station-4) and at its top in the vertical direction (Station 5, not shown). B and K vibration and noise measurement and analyses equipment were used.

Balancing the Multi-mass Rotor

Dynamic balancing of multi-mass thresher rotor was carried out in the laboratory by running the rotor at a constant speed and without feeding the crop. The rotor was considered to be a rigid one, as it operated at a speed of 820 rpm, which is sufficiently below its critical speed of 1 685 rpm (Rao, et al., 1985). A rigid rotor need not be balanced by running it at its operating speed. The thresher rotor speed was varied gradually from 0 to 1 200 rpm to find the speed(s) at which the thresher frame had large resonant response. For the end conditions provided by its being fixed to the floor, the thresher frame was found to resonate at rotor speed of 620 rpm and had large amplitude in the lateral direction.

To avoid resonance, a speed of 600 rpm was selected for experimental investigations. A trial weight of 165 g (1.62 N) was used to locate the angular position of the imbalance on the flywheel end. The trial weight was slided along the flywheel rim through 10° interval and the response at flywheel end (Station-1) was recorded. The angular position of the weight for minimum response was 315°. At this angular position the weight that gave the least response was also found. With this balance weight in position, the system was balanced at the pulley end (Station-2) by following the same procedure and running the rotor at the same speed. The above procedure of alternately balancing the flywheel end and then the pulley end had to be repeated only a couple of times until the system was balanced and no change either in the location or amount of balance weight was necessary. This showed fast convergence. The final location and extent of balance weights for both planes are given in **Table 1** and the total imbalance was 7 900 (77.5) + 35 400 (347.3) = 43 300 g-mm (425 N-mm). As the thresher rotor weighs 139.15 kg (1 365 N), the imbalance removed was 43 300/139.15 = 311.5 g-m/kg

Table 1. Balance Weights and Their Locations

Balancing Plane/end	Angular ptn., deg.	Radial ptn., mm	Balance wt., g(N)	Unbalance g-mm (N-m)
Flywheel	315	395	20 (0.2)	7900 (77.5)
Pulley	300	295	120 (1.18)	35400 (347.3)

(311.5 x 10^{-6} N-m/N) body weight of the rotor.

Balancing of Reciprocating Masses

A sieve weighing 29.16 kg (286 N) was given a reciprocating motion through a driving mechanism with eccentricity r = 7.5 mm and connecting rod length of l = 120 mm. For such high values of the ratio l/r (= 16), higher harmonics of periodic excitation force arising from the reciprocating motion of the sieve are negligible (Ghosh and Mallik, 1976). The oscillatory motion of the sieve can thus be considered to be sinusoidal. The driving pulley that was used to mount the counterbalance weight was statically balanced (Bansal and Gandhi, 1996) by adding a weight of 210 g at a radius of 85 mm and at appropriate angular position. Weights required for balancing different percentages of the total reciprocating mass (Bansal, et al., 1992) were mounted on the driving pulley and 60% counter balancing was optimum for least vibrational response.

Dynamic Performance Under Field Conditions

The field conditions under which the threshers operate are different from those in the laboratory. In the field, the thresher rotor operates at 820 rpm while actually threshing the crop. It rests on its transportation metallic wheels which get partly embeded into the loose soil. The effect of balancing on the vibration control was thus necessary to be studied under the actual field conditions also. The response at Stations-1 and -2 was recorded over a range of frequency with the thresher balanced and imbalanced, while it operated under threshing load and under no-load conditions.

Results and Discussion

Results of the experimental studies conducted under laboratory conditions are presented in **Figs. 2** to **4** and those conducted under field conditions are presented in **Fig. 5**.

Effect of Balancing of Reciprocation Masses

Fig. 2 compares the responses (acc, m/sec^2) in the horizontal (**Fig. 2[a]**, Station-4) and the vertical (**Fig. 2[b]**, Station-5 not shown) directions at different 1/3 octave band centre frequencies, before and after balancing the reciprocating masses. The peak value of acceleration level in the horizontal direction at 124 Hz was lowered from 4.9 to 2 m/sec^2 — a significant reduction of 59.2%.

Effect of Dynamic Balancing of the Rotor

Fig. 3 compares the vibration level at the flywheel end (**Fig. 3[a]**, Station-1) and the pulley end (**Fig. 3[b]**, Station-2) at 1/3 octave band centre frequencies, before and after balancing the multi-mass thresher rotor. These results show a reduction of 80.7% and 78.4% of the highest response peaks at the pulley end and the flywheel end, respectively. Considering the peak response values to be proportional to the imbalance, the residual imbalances can be determined (**Table 2**).

The total residual imbalance 76.48 g-mm/kg (76.48 x 10^{-6} N-m/N)

Table 2. Residual Imbalance, g-mm/kg (N-m/N) Body Weight

Balancing plane	Imbalance removed	Original imbalance	Residual imbalance
Flywheel end	56.77	72.41	15.64
Pulley end	254.40	315.24	60.84
Total	311.17	387.65	76.48

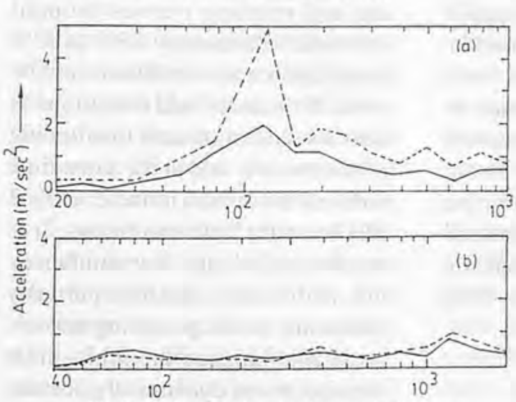

Fig. 2 Effect of counter balancing of the reciprocating masses in the horizontal direction (a) and in the vertical direction (b). -------, before balancing; ____, after 60% balancing.

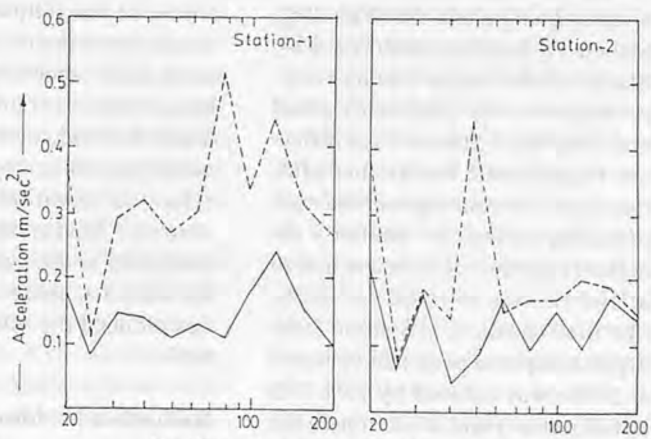

Fig. 3 Effect of dynamic balancing of thresher rotor on vibration levels at Station-1 (Stn. 1) and Station-2 (Stn. 2). -------, before balancing; ____, after balancing.

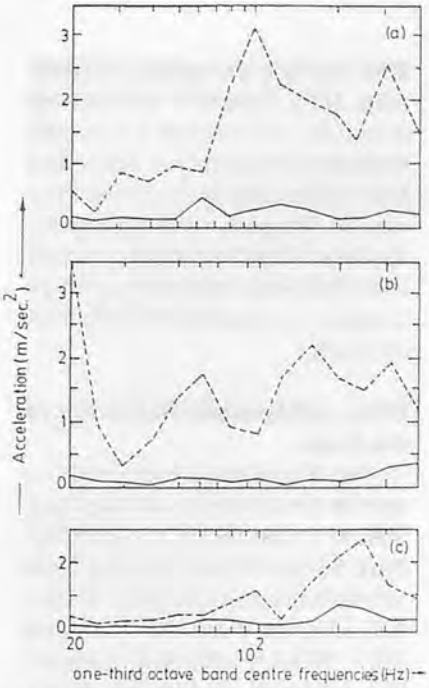

Fig. 4 Effect of balancing of reciprocating and rotating masses and couples at (a) Station-1 (Stn.1), (b) Station-2 (Stn.2) and (c) Station-3 (Stn.3). -------, before balancing; ____, after balancing.

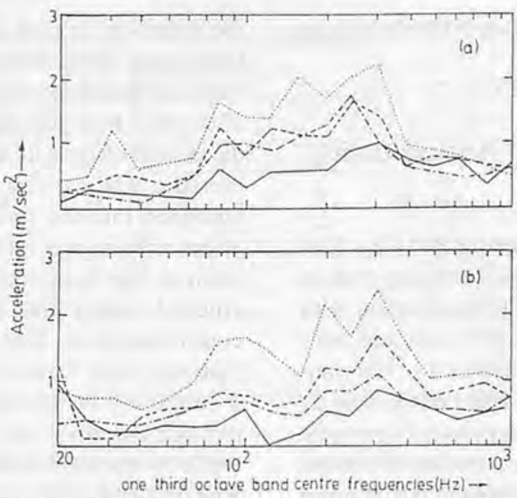

Fig. 5 Effect of balancing studied under field conditions at Station-1 (Stn.1), (a); Station-2 (Stn.2), (b).
........, before balancing and without threshing;
-------, while threshing before balancing;
_._._., after balancing and without threshing;
______, while threshing after balancing.

body weight, which is considerably low as compared to 160 g-mm/kg body weight — a value permissible for the agricultural machinery as per ISO (194-1973(E)). The imbalance has been reduced by 80.3%.

Combined Effect of Balancing of Reciprocating and Rotating Masses

Fig. 4 compares the vibration level at the flywheel end (**Fig. 4[a]**, Station-1), the pulley end (**Fig. 4[b]**, Station-2) and at the member supporting the rotor shaft at flywheel end (**Fig. 4[c]**, Station-3) at different frequencies; before and after balancing the rotating and the reciprocating masses. At Station-1 the highest response peak that occurred at 100 Hz was lowered by 90.3% (3.1 to 0.3 m/sec^2), at Station-2, the highest response peak that occurred at 20 Hz was reduced by 95% (3.5 to 0.2 m/sec^2) and at station-3, the maximum amplitude at 200 Hz was reduced by 75% (2.8 to 0.7 m/sec^2). This shows that balancing of both reciprocating and rotating masses improves the dynamic performance of the thresher considerably.

Dynamic Performance under Field Conditions

Under field conditions, the thresher rotor was operated at its normal speed of 820 rpm, with and without the threshing going on and while the thresher was in balanced and imbalanced condition. **Fig. 5** compares the response at the flywheel end (**Fig. 5[a]**, Station-1) and the pulley end (**Fig. 5[b]**, Station-2) under different combinations of these conditions. Almost over the whole of the frequency range covered, threshing of the crop caused damping irrespective of the thresher being balanced or imbalanced. Even under the field conditions it may be noted that balancing has a marked effect on vibration control at the source. Depending upon the frequency of the peak response and the station of observation, balancing has reduced the vibration by 40 to 60%.

Reduction in Noise Level

Noise levels were measured close to the ear of the operator while threshing the wheat crop in the field with the thresher in the balanced and imbalanced conditions. Balancing has reduced the overall noise levels by about 2 dB(A).

Conclusions

The simple method, which is somewhat similar to the method of sequential minimization of structural response, was very effective for in-place dynamic balancing of the rigid multi-mass thresher rotor. Counter balancing the reciprocating masses to the extent of 60%, was the most effective in reducing the vibration. Balancing of both reciprocating and rotating masses brought down the vibration by 75% to 90% under laboratory conditions and by about 60% under field conditions. It also resulted in smooth functioning of the thresher and at the same time reduced the overall noise level by 2 dB(A) under field conditions. It is recommended that the manufacturers of threshers, besides partially balancing the reciprocating masses, must also balance the multi-mass thresher rotors dynamically in order to prolong their fatigue life and avoid malfunctioning.

(Continued on page 42)

Evaluation of Two Mechanized Operations for Kenaf (*Hibiscus cannabinus* L.) in the Sudan

by
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Abstract

This paper reports on two major mechanized operations for kenaf: land preparation and harvesting. Ploughing time on the 15th of March, April and May, and ploughing depths of 8, 12, 16 and 20 cm were tested for kenaf in split-plot design experiment. The crop showed no significant response to the treatments. Moreover, the problems facing manual harvesting of kenaf were discussed. Suggestions are made for improving the use of existing kenaf harvesters and decorticator. Mechanical harvesting is the only solution for improving kenaf production in the Sudan.

Introduction

Improved timeliness of harvesting is essential for obtaining a good quantity and quality of kenaf fibre. Therefore, land preparation should be done at the proper time, specially in Abu Naama kenaf scheme, which is 2-course rotation of kenaf and groundnut cropping. The alloted area for each crop is 6 300 ha. The optimum sowing date of kenaf is 15th of May (Salih, 1969) which usually coincides with time of groundnuts sowing. This is the peak period for machinery requirements to prepare the land and to sow the crops. However, the scheme authorities attribute the low yield of kenaf fibre (1.0 t/ha) to the use of disc harrow to a depth of 8 cm year after year. This 1.0 t/ha yield includes the loss of fibre in the field (10%) and in the bags factory (30%) (Ali, 1986). A general rule stated by Culpin (1976), was 20-35 cm depth of ploughing for root crops and 15-20 cm for most other crops. The increase in depth from 15-20 cm improves for oxidation and use of water supply.

The major objectives of tillage in the Central Clay Plain in the Sudan are to break soil strength for better crop establishment and eradication of weeds.

Abu Naama soil is part of Central Clay Plain which is montmorillonitic clay soil (Hack, 1970). It is a heavy black clay soil that is characterized by swelling and shrinkage phenomena, and wide and deep cracks during dry periods.

Tillage experiment was conducted for two seasons (1984/85 and 1985/86) at Kenana Research Station/Aub Naama in order to evaluate the effects of ploughing time and ploughing depth on kenaf with the objectives of increasing fibre yield and effective use of machineries in order to avoid bottle-necks in farm machinery requirements.

Harvesting is another major problem hampering kenaf yield and production in the Sudan (**Tables 6** and **7**). Therefore, this paper touches also on harvesting difficulties and future prospects of solving the problems in kenaf yield and production.

In accordance with the two mentioned constraints, the study is divided into two parts, which are:

a) Effects of ploughing time and ploughing depth for kenaf production; and
b) Kenaf harvesting (a case study).

Effects of Ploughing Time and Ploughing Depth on Kenaf Production

Materials and Methods

The experiment was conducted on a land area that was infested by "Ankog" *Ischaemum afrum* using a split-plot design with three replications. Ploughing time was assigned to main plots which were 15th of March, April and May. The ploughing depths were allocated randomly in subplots within each mainplot which were 8, 12, 16 and 20 cm. The experimental land was prewatered four weeks before the first ploughing date in order to enhance weeds germination and to break soil hardness. A chisel plough with rigid tines was used. For ploughing depths of 8 and 12 cm, the chisel plough tines were spaced 25 cm apart in order to secure complete

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soil breakage, but for the 16 and 20 cm depth the tines were reset at 36 cm apart. At sowing time the ploughed subplots were harrowed in order to make a fine seedbed. The sunplot size was 4 x 8 m and the harvestable area was 3 x 3.5 m. Kenaf (CV.G.F.55) was sown by a seed drill using a spacing of 20 cm between rows and 10 cm between plants, and seedrate of 8.6 kg/ha. Urea was added at the rate of 95 kg/ha and the crop was irrigated every 14 days. Hand weeding was carried out four weeks after crop emergence.

The crop germination was commenced on 18th of May and 25th of May in the 1984/85 crop and season 1985/86, respectively. The crop was cut manually at 10% flowering stage.

Results and Discussion

The mean of plant height, total fresh weight, fresh ribbon weight, and dry ribbon weight are shown in **Tables 1, 2, 3 and 4**, respectively, while **Table 5** shows the means of the above parameters for the two seasons.

The two-year study revealed the following:

1. There were no significant differences for all the parameters with regard to ploughing time. Therefore, the land for kenaf can be prepared when the soil is workable; that is, after groundnut harvesting to make use of available soil moisture, and after pre-watering to break down the soil composition.

2. Similarly, there were no significant differences for all the parameters studied regarding ploughing depth. This may pos-

Table 1. Effects of Ploughing Time and Ploughing Depth on Kenaf Plant Height (Unit: cm)

Ploughing Depth	1984/85 Season			
	Mid-March	Mid-April	Mid-May	Mean
8	110	114	107	110
12	115	131	107	118
16	108	119	106	111
20	117	116	124	119
Mean	113	120	111	115
Standard errors between any:				
2 ploughing time mean				= ±11
2 ploughing depth mean				= ±6
2 ploughing depth mean of the same ploughing time				= ±10
2 ploughing time mean of the same ploughing depth				= ±14
	1985/86 Season			
8	127	134	126	129
12	147	113	126	129
16	126	138	132	132
20	139	135	126	133
Mean	135	130	127	131
Standard errors between any:				
2 ploughing time mean				= ±9
2 ploughing depth mean				= ±7
2 ploughing depth mean of the same ploughing time				= ±12
2 ploughing time mean of the same ploughing depth				= ±14

Table 2. Effects of Ploughing Time and Ploughing Depth on Kenaf Total Fresh Weight (Unit: t/ha)

Ploughing Depth (cm)	1984/85 Season			
	Mid-March	Mid-April	Mid-May	Mean
8	17.8	23.3	15.7	18.9
12	22.1	27.4	17.1	22.2
16	21.7	21.9	17.6	20.4
20	23.1	22.1	24.3	23.2
Mean	21.2	23.7	18.7	21.2
Standard errors between any:				
2 ploughing time mean				= ±3.8
2 ploughing depth mean				= ±2.4
2 ploughing depth mean of the same ploughing time				= ±4.3
2 ploughing time mean of the same ploughing depth				= ±3.6
	1985/86 Season			
8	42.1	23.6	32.4	32.7
12	32.1	17.9	29.0	26.3
16	38.3	27.1	30.5	32.0
20	35.5	29.8	27.4	30.9
Mean	37.0	24.6	29.8	30.5
Standard errors between any:				
2 ploughing time mean				= ±5.2
2 ploughing depth mean				= ±3.3
2 ploughing depth mean of the same ploughing time				= ±6.0
2 ploughing time mean of the same ploughing depth				= ±7.1

Table 3. Effects of Ploughing Time and Ploughing Depth on Kenaf Fresh Ribbon Weight (Unit: t/ha)

Ploughing Depth (cm)	1984/85 Season			
	Mid-March	Mid-April	Mid-May	Mean
8	10.0	12.6	8.3	10.3
12	13.1	14.8	9.3	12.4
16	12.9	12.6	9.0	11.5
20	12.1	11.9	13.1	12.4
Mean	12.0	13.0	10.0	11.7
Standard errors between any:				
2 ploughing time mean				= ±2.1
2 ploughing depth mean				= ±1.9
2 ploughing depth mean of the same ploughing time				= ±3.3
2 ploughing time mean of the same ploughing depth				= ±3.6
	1985/86 Season			
8	6.9	7.6	6.7	7.1
12	6.7	5.5	7.6	6.6
16	6.7	9.3	7.6	7.9
20	8.8	7.9	7.4	8.0
Mean	7.3	7.6	7.3	7.4
Standard errors between any:				
2 ploughing time mean				= ±1.7
2 ploughing depth mean				= ±0.7
2 ploughing depth mean of the same ploughing time				= ±1.2
2 ploughing time mean of the same ploughing depth				= ±1.9

Table 4. Effects of Ploughing Time and Ploughing Depth on Kenaf Dry Ribbon Weight (Unit: t/ha)

Ploughing Depth (cm)	1984/85 Season			
	Mid-March	Mid-April	Mid-May	Mean
8	3.1	3.1	2.1	2.8
12	3.6	4.0	2.9	3.5
16	3.3	3.1	2.1	2.8
20	3.3	3.8	3.1	3.4
Mean	3.3	3.5	2.6	3.1
Standard errors between any:				
2 ploughing time mean				= ±0.7
2 ploughing depth mean				= ±0.5
2 ploughing depth mean of the same ploughing time				= ±0.7
2 ploughing time mean of the same ploughing depth				= ±1.0
	1985/86 Season			
8	4.0	3.1	3.6	3.6
12	4.0	2.6	4.0	3.5
16	4.8	3.3	3.8	4.0
20	5.2	3.8	3.8	4.3
Mean	4.5	3.2	3.8	3.8
Standard errors between any:				
2 ploughing time mean				= ±0.5
2 ploughing depth mean				= ±0.5
2 ploughing depth mean of the same ploughing time				= ±1.0
2 ploughing time mean of the same ploughing depth				= ±1.0

Table 5. Effects of Ploughing Time and Ploughing Depth on Kenaf Over Two Years Old

Ploughing Depth (cm)	Means, 1984/85, 1985/86							
	Mid-March	Mid-April	Mid-May	Means	Mid-March	Mid-April	Mid-May	Means
	Plant Height (cm)				Fresh Ribbon Weight (t/ha)			
8	119	124	117	120	8.6	10.2	7.6	8.8
12	131	122	117	123	10.0	10.2	8.6	9.6
16	117	129	119	122	9.8	11.0	8.6	9.8
20	128	126	125	126	10.5	10.0	10.2	10.2
Means	124	125	120	123	8.7	10.4	8.8	9.6
	Total Fresh Weight (t/ha)				Dry Ribbon Weight (t/ha)			
8	30.0	23.6	24.0	25.9	3.6	3.1	2.9	3.2
12	27.1	22.6	23.1	24.3	3.8	3.3	3.6	3.6
16	30.0	24.5	24.0	26.2	4.0	3.3	3.1	3.5
20	29.3	26.0	26.0	27.1	4.3	3.8	3.6	3.9
Means	29.1	24.2	24.3	25.9	3.9	3.4	3.3	3.5

sibly be due to the phenomena of soil swelling and shrinkage after wetting and drying which upsets the effect of tillage that does not last long. Therefore, in such soils a shallow ploughing (minimum tillage) is quite enough and economical. Moreover, large areas can be prepared in a short time.

3. There was no indication for interaction between ploughing time and ploughing depth.

Kenaf Harvesting (A Case Study)

The Abu Naama area is characterized by the scarcity of labour for kenaf harvesting operations. Most of the people are either working in the private sector or are nomads. Moreover, there are difficulties in recruiting labour that consist of boys and girls from the scuttered villages to the scheme.

Kenaf harvesting time is the peak period for hand labour. **Table 6** indicates that fibre production from one ha of planted area requires 154 labour (Ali, 1986). Unfortunately this time coincides with harvesting of the traditional crops in the area, e.g., sesame and sorghum, where accomodation and food are supplied free by the private sector farmers, in contrast with kenaf scheme. Labourers prefer cutting sesame and practices in harvesting sorghum to kenaf, as the latter has the following problems: a) difficult to cut; b) spines are sharp; c) lower remuneration; d) wild stinging bees are usually present in kenaf plantations; and e) relatively weaker hands of young boys and girls labourers.

Due to the foregoing problems and the sensitivity of fibres to harvesting time, only small areas were planted to kenaf yearly compared with the total alloted area of 6 300 ha. **Table 7** (Ali, 1986) shows that the maximum planted area was 55% and 53% for the seasons 1976/77 and 1977/78, respectively. This was the time when two types of kenaf harvesters were introduced to the scheme. As a result, the planted area was reduced, hence the number of harvesters was reduced by 5% for the total area. Therefore, mechanical harvesting is the only solution for kenaf production in the Sudan.

The existing harvesters now in the Sudan are of low efficiency and short life-span. These are Seiga-binder and Rote-gard. In addition, the available decorticator has also some problems that should be solved.

The main features of the Seiga-binder and Rote-gard machines, including suggestions for their improvement are as follows:

The Seiga-binder — Five Seiga-binders were introduced to the scheme in 1976, but they were scrapped before 1982 (A. Gadir, 1986). Their functions are to cut the kenaf stalks and bind them by automatic knotter. It consists of a horizontal reciprocated mower, and two chains passing through gears carrying rods with fingers to remove

Table 6. Labour Requirements for Kenaf Harvesting

Harvesting Operation	No. of Labours Required/ha
Cutting stalks	29
Stalks collection and decortication	38
Fibre binding	14
Fibre transportation	10
Unloading of fibre for retting	7
Fibre washing and spreading to dry	36
Fibre refining	10
Fibre bailing	10
Total	154

Table 7. Planted Area to Kenaf

Season	Planted Area (ha)	% Planted Area to Total Area
1976-77	3 439	55
1977/78	3 360	53
1978/79	2 307	37
1979/80	1 661	26
1980/81	1 308	21
1981/82	375	6
1982/83	312	5
1983/84	330	5
1984/85	Noplanting	—
1985/86	874	14

the cut stalks in a vertical position to the bundle compartment for knotting. The machines consists many moving parts, which is why they do not last long. Moreover, they often get stuck by kenaf stalks that reduce the rate of work even as their of cut is about 2 m each.

The following modifications are suggested for the improvement of these harvesters:

1. An adjustable reel should be incorporated in order to raise or lower the machine according to plant height; and

2. Eliminate the knotter mechanism and instead leave the stalks in loose bundles.

The Roto-gard — Five of the Roto-gard machines out of 35 were working from 1976 up to 1986. This type of machine has the following problems (A. Gadir, 1986):

1. Stalk cutting height ranged between 20 and 30 cm above the ground. This portion contains high fibre quality, hence the yield is adversely affected;

2. Narrow width of cut of only about 60 cm;

3. Time loss for repairs and

maintenance exceeds the actual working time;

4. The belt driving the discs with knives often slips off; and

5. The machine cannot work if climbing weeds are present in the field, such as "Tabar" (*Ipomoea cordofana*).

The following modifications are suggested:

1. Increase the width of cut by the addition of another two rotating discs with knives;

2. Change the belt driving discs to a chain; and

3. Fix at the edge of the machine, and slightly in front of the cutting units, small rotating knives or reciprocated mower to cut the climbing weeds that connect the cut stalks with the standing ones.

The kenaf decorticator — The available type of decorticator at the Abu Naama scheme that emits great and unbearable noise. In addition, it is not very safe for labourers who manually feed the machine. Many accidents have been reported during the feeding process.

The following are suggested for its improvement:

1. Reduce the noise of the driving machine; and

2. Automatic elevator should be fixed to the front of the decorticator for stalk elevation.

Conclusions and Recommendations

1. Ploughing time and ploughing depth had no significant effect in increasing kenaf yield. Therefore, the land can be prepared when the soil is workable to a shallow depth (minimum tillage), but fine seedbed; and

2. Harvesting is the major problem limiting kenaf production. Mechanical harvesting is the only solution for expanding kenaf planted area. Unless the existing kenaf harvesters are improved or new highly efficient makes are available, commercial kenaf production will continue to be jeopardized.

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Dynamic Balancing of a Rigid Multi-mass Thresher Rotor and Vibration Control

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Practical Approach to Water Quality Improvement in Agricultural Areas

— Soil and water engineering with practical application (1) —

by
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Abstract

The USA and the EC nations face problems of groundwater pollution, especially by nitrate, and regulate the use of agricultural chemicals and fertilizers in regions that serve as sources for drinking-water supply. Japan has a large acreage of paddy fields and a land-use structure comprising forests, paddy fields, and vegetable fields. Paddy fields are located on topographically lower lands, while vegetable fields are on upper areas. Nitrogen load generated on high lands is removed in downstream paddy fields. Such a natural topographic chain removes nitrogen. Abandoned and devastated paddy fields lose their capacity for flood control. As a result, they cannot cultivate water resources, which leads to the deterioration of water quality and thus pollution of groundwater and lakes. These things rebound against the cities. We should recognize and conserve paddy fields as areas necessary for preserving water quality. The ability of paddy fields for removing nitrogen should be effectively utilized. However, paddy fields are for agricultural production and not for waste water treatment. We must create fields that are both productive and able to conserve water quality.

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Introduction

The earth does not belong only to people living today but also to the coming generations. It is our duty to hand down a green and healthy earth, which we have inherited from our ancestors, to our children. However, the global environment is now a big issue. Especially, many kinds of problems relating to water pollution have arisen in modern agricultural areas in the world: water pollution of rivers and lakes, pollution of irrigation water, control of industrial waste water, treatment of sewage and excrement by livestock, and outflow of chemicals and fertilizers from the fields (Tabuchi, 1989), as shown in **Fig. 1**. These areas have used polluted irrigation waters from agricultural lands, factories and towns, following an increase in remarkable human activities.

The polluted water contains much nitrate nitrogen. When we drink the polluted water, much nitrate nitrogen is taken by the human body to cause a poisoning or, if a baby drinks it, it causes a blue-baby symptom. Whereas nitrogen is an essential substance for agriculture because plants grow well by absorbing nitrogen applied as ferti-

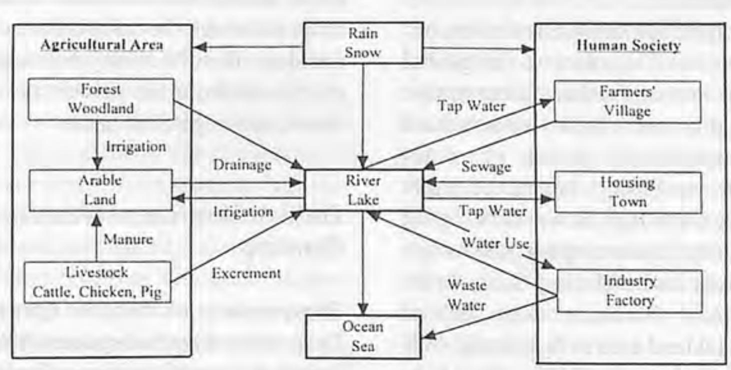

Fig. 1 Water quality problem in an agricultural area.

lizers. Excess nitrogen adversely affects not only agriculture but also human existence. Effective utilization and wise reuse of nitrogen in agricultural areas are important.

The purpose of this paper is to consider the water quality conservation and improvement in individual nations, villages, or farmland areas, to explain these phenomena, and to answer the question of how modern agricultural water management should be conducted.

Forests and Agricultural Land

The Environment Conference of the United Nations (Earth Summit), which was held in 1992 in Rio de Janeiro, Brazil, deliberated upon treaties and projects for leaving the coming generations a healthy earth and marked the beginning of a new era in the conservation of the global environment. This Conference was so important that may become noted in history. There are many environmental issues that must be addressed globally, including global warming by green-house-effect gases such as carbon dioxide, extinction of plants and/or animal species due to deforestation, acid rain and resulting forest damage, rapidly advancing desertification, food shortage, and increasing population. However, national boundaries inhibit global actions and create serious conflicts of interest.

A typical example is forest conservation. To preserve the global environment, further deforestation should be prevented. Conservation of tropical rain forests is an absolute necessity. However, such measures weigh down developing countries in developing agricultural lands and utilizing their forest resources. Forests occupy 59% of the total land area in Indonesia, 48% in South America, 31% in the USA, 22% in Italy, and only 9% in the Netherlands (FAO, 1994). Developed countries that have deforested their land to convert it for agricultural uses may be considered selfish.

Forests in Japan occupy more than 60% of its total land area, a very high percentage among developed countries. Thus, Japan may be able to take a stance intermediate between developed and developing countries. Systematic measures must soon be taken by the entire earth, each continent and each nation, to maintain a certain level of forest areas.

Developed countries should afforest their land areas as well as demand that developing countries restrict deforestation. European nations are not only preventing deforestation but are actively replanting forests mainly to conserve water. When forests are converted into agricultural land, agricultural chemicals and fertilizers, especially nitrogen, penetrate the ground and pollute groundwater and, as a consequence, drinking water. In areas where drinking water supply sources are located, use of agricultural chemicals and fertilizers is controlled, and some agricultural lands are even converted into forests.

The degree of groundwater pollution in an area depends on its land use and the ratio of forest to agricultural land. Vegetable and paddy fields, which are both agricultural lands, differ significantly as discussed later. The amount of fertilizers used differs for each kind of crop. Although the calculation is not absolute, the effect may be roughly computed from the percentages of forest and vegetable areas.

Determination of Water Quality

Expression of Water Quality Determined by Substances Existing in Water (Concentration and Load)

The water we use daily is not pure H_2O but contains various other substances. These substances affect "water quality," but the change in water properties caused by these substances, such as density, viscosity, pH, alkalinity, electrical conductivity, temperature, turbidity, and transparency, also indicate water quality and is expressed in various notations. A basic expression for substances existing in water is "concentration".

Concentration (*mg/l*)
= amount of substance (mg) / amount of water (*l*)

Various units are used to express concentration, but (*mg/l*) and (ppm) are the most widely used. The unit *mg/l* means milligrams of a substance in 1 *liter* of water, while ppm means parts per million. One million grams is 1 ton, which is almost 1 m^3 in water. When 1 m^3 of water contains 1 gram of a substance, the concentration of the substance is 1 ppm. Therefore,

1 ppm = 1/1 000 000 = 1 g/1 t
→ 1 g/m^3 = 1 *mg/l*

1 ppm is numerically equal to 1 *mg/l*.

Load signifies the amount of a substance in water. Therefore, load is calculated by multiplying concentration by water volume, i.e.,

Load (mg) = concentration (*mg/l*) x water volume (*l*)
or
Load (g) = concentration (*mg/l*) x water volume (m^3)

For example, if 2 000 m^3 of water containing 3 *mg/l* of a substance is used to irrigate 10 ares of agricultural land, (hereafter, 10 ares shall be expressed as 10a)

Load = 3 (*mg/l*) x 2 000 (m^3/10a)
= 3 (g/m^3) x 2 000 (m^3/10a)
= 6 000 (g/10a)
= 6 (kg/10a)

60 (kg/ha),

hence, 60 kg of the substance is spread over 1 ha of agricultural land.

Classification of Substances which Determine Water Quality

Various substances are contained in water. This section discusses nitrogen. Nitrogen exists in water as organic nitrogen, ammonia, nitrate, and nitrite. Nitrogen changes its form in water and is thus difficult to measure.

The sum of all these forms is called total nitrogen (T-N).

Inorganic nitrogen = ammonia nitrogen + nitrate nitrogen + nitrite nitrogen.
(Inorg.-N = NH_4-N + NO_3-N + NO_2-N)
Total nitrogen = inorganic nitrogen + organic nitrogen.
(T-N = Inorg.-N + Org.-N)
Therefore, T-N = NH_4-N +NO_3-N + NO_2-N + Org.-N.

NO_3 and NO_3-N are confusing. One *mg/l* of NO_3 signifies 1 mg of nitrate, not 1 mg of nitrogen, existing in 1 *liter* or water. The molecular weight of NO_3 is 62, the sum of N: 14 and O:16 x 3. Therefore, the ratio of N contained in NO_3 is 14/62 = 0.226 or 22.6%. The amount of N contained in 1 mg of NO_3 is 0.226 mg. This value is called nitrate nitrogen (NO_3-N).
Therefore,
$[NO_3] \times 0.226 = [NO_3\text{-}N]$.
The same is applied to ammonia nitrogen, i.e.,
$[NH_4] \times 0.778 = [NH_4\text{-}N]$.

Pollution of Groundwater by Nitrate

Nitrogen contained in chemical fertilizers when applied to farmland is usually oxidized and changes into nitrate. Nitrogen contained in fermented fish scrap or manure is degraded and is also finally converted into nitrate. Nitrate, which is an anion, is generally little adsorbed by soil and is easily dissolved in rain or irrigation water and percolates underground. Thus, the application of fertilizers exceeding the amount absorbed by crops causes nitrate pollution of groundwater.

Groundwater polluted with nitrate causes toxication, blue-baby symptoms, and eutrophication of rivers and lakes. Excessive nitrate from agricultural land is a serious issue.

A vast area of the former East Germany faces groundwater pollution by nitrate released from livestock excrements. A large number of livestock have been raised, and their excrement has long been spread over farmland, polluting one-third of it. This is a serious problem for those areas where groundwater is used for drinking.

A region in the former West Germany started to regulate the utilization of agricultural chemicals and fertilizers to conserve the quality of groundwater. However, farmers complain that the regulation makes farming difficult.

Japan's situation is not as bad as those in the European nations. This is attributable to its mountainous land, large forest areas, and paddy fields, which occupy a large percentage of the farmland. Forest should be appraised not only for its ability to control floods and hold water, but also for its capacity to conserve water quality. Paddy fields, which are covered with water, keep the soil reduced and inhibit conversion of nitrogen into nitrate. Moreover, paddy fields release nitrogen to the atmosphere, i.e., they perform "denitrification". Thus release of nitrate is significantly less than in vegetable fields. Forests and paddy fields avoid nitrate pollution. Therefore, Japan has not suffered serious nitrate pollution of groundwater.

However, high nitrate pollution is locally observed in certain districts where forests are scarce and there are heavily fertilized vegetable fields, orchards, or tea fields. Nitrate concentrations far exceeding the standard value were observed in some heavily fertilized vegetable fields and livestock farms.

This can be explained by a simple calculation that, for example, if a vegetable field is fertilized with 500 kg/ha of nitrogen, of which 30% eluviates, 150 kg of nitrogen eluviates from each hectare of the field. Let 1 000 mm of rain or/and irrigation water permeate the soil or 10 000 m^3 per ha. Eluviated nitrogen of 150 kg dissolved in this amount of water makes a mean concentration of 15 *mg/l* . This value exceeds the Japanese standard concentration of nitrate nitrogen in tap water: 10 *mg/l* . Groundwater should be closely watched in districts where some heavily fertilized vegetable fields are concentrated. Forests generally exist in these areas, and the actual values are lower. If forests occupy 50% of the area, the nitrate concentration should be about half of this value (Tabuchi and Takamura, 1985). Appropriate ratios of forests and vegetable fields are vital in districts that serve as sources of water supply.

Amounts of fertilizers applied are also important. Since the amount of fertilizers used in heavily fertilized vegetable fields is double or triple that used in lightly fertilized bean or potato fields, cultivation and application projects in a district should consider nitrogen load over the entire area. Obviously, the population of livestock and treatment of excrement are important issues. The Netherlands, which raises pigs extensively, produces more excrements than can be used in its total farmland area and exports it to foreign nations. Excessive application of manure invites underground water pollution as seen in the former East Germany.

Measures Taken in USA and EC Nations

Various agricultural and environmental measures are taken in the USA and the EC nations to promote earth-friendly agriculture. In 1985, the USA passed agriculture acts including "soil conservation" and "wetland preservation". The agriculture acts of 1990 expanded and enhanced environmental conservation measures in agriculture, which included liability for registering usage of dangerous agricultural chemicals and projects encouraging conservation of water quality by reducing the use of agricultural chemicals and fertilizers. Emphasis on "wetland" conservation is especially notable. Wetlands in the USA are being converted into agricultural uses and are rapidly disappearing. The acts aim to preserve wetlands for environmental conservation, flood control, and conservation of water quality. "Wetland penal regulations" were established, which punish people/organizations destroying wetland by stopping federal financial help. Wetlands are considered to be very beneficial for environmental conservation. "Paddy fields" are certainly playing the roles of "wetlands".

The USA is deeply concerned about agriculture from the viewpoint of environmental conservation because it faces a serious drinking-water pollution problem and there are active movements by environmental organizations.

The EC nations also face problems of groundwater pollution, especially by nitrate, and regulate the use of agricultural chemicals and fertilizers in regions that serve as the sources of drinking-water supply. Pollution is especially serious in districts where mountains and/or forests are scarce. The Netherlands is a typical case. The Netherlands is a flat country with very few mountains, is one of the world biggest livestock nations, and is located at the downstream end of the Rhine, in which nitrogen concentration is significantly high due to water pollution in the upstream region. Because of these bad conditions, the government of the Netherlands has started to regulate the treatment of livestock excrement and its dispersal.

Germany regulates agricultural chemicals and chemical fertilizers in districts that serve as sources of drinking water. Most of the other EC countries encourage and subsidize agriculture that uses few agricultural chemicals and fertilizers, i.e., extensive agriculture and organic agriculture.

Nitrate Pollution in Japan

Japan is mountainous, has forest covering 66% of its total land area, and is blessed with abundant clean water. As a total, Japan does not yet face a pollution problem as serious as those in the EC and the USA. However, contamination is serious in vast agricultural zones where drinking water is taken from underground and in reservoirs and lakes located downstream of cities or agricultural zones. Pollution of groundwater and surface water by agricultural chemicals and nitrogen should be carefully watched.

Movement of nitrogen in a Japanese agricultural area, which causes nitrate pollution, is shown in **Fig. 2**. Today, rain contains a considerable amount of nitrogen due to air pollution. With rain, 10 kg of nitrogen falls on each ha of land annually (Tabuchi et al., 1979). (Hereafter, this shall be expressed as 10 kg•N/ha.) However, the amount of nitrogen discharged from forest is only 3~5 kg•N/ha (Kunimatsu, 1994). These figures, 10 kg•N/ha and 3~5 kg•N/ha, are obviously very rough and may vary significantly, but they are sufficient to show that forest reduces 10 kg•N/ha nitrogen to 3~5 kg•N/ha. In other words, the forest

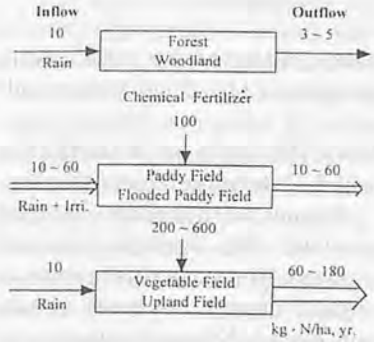

Fig. 2 Nitrogen outflow in three types of land use.

has the capacity to remove nitrogen, and this keeps river water clean in the mountainous regions of Japan.

However, vegetable fields are fertilized as well as receiving 10 kg•N/ha nitrogen from rain. Nitrogen fertilizer that is not absorbed by crops is discharged. The amount of fertilizer with the kind of crop varies, so the amount of discharge also varies. Vegetable fields show the most serious problems. Vegetable fields are generally heavily fertilized: 5 to 6 times more than paddy fields. Highland celery fields, especially show very large figures of 60 kg•N/ha to 180 kg•N/ha (Tabuchi and Takamura, 1985). Livestock farms on plateaus also show high nitrate nitrogen concentrations of 50 *mg/l* to 100 *mg/l* in groundwater (Tabuchi, 1986). This is attributable to livestock excrement collected in storage ponds constructed by simply digging holes in the ground. Nitrogen from these vegetable fields and storage ponds percolates underground, reacts chemically, changes to nitrate nitrogen, and causes nitrate pollution of groundwater. The EC nations face serious nitrate pollution because they have less forest than Japan, and, of course, almost no paddy fields, vast vegetable fields, and a large livestock industry. Heavily fertilized land and an active livestock industry cause nitrate pollution of groundwater.

Discharge of Nitrogen from Paddy Fields

Paddy fields are substantially different from vegetable fields and livestock farms. This difference is attributable to the abundant irrigation water as well as rain. The annual mean precipitation in Japan is about 1 800 mm. In addition, paddy fields are irrigated with more than 2 000 mm of water. In other words, water totaling double the amount of precipitation is introduced. Naturally, the amount of water discharged from paddy fields is also double. Since such abundant water must move, paddy fields were once suspected of releasing a lot of nitrogen. The amount of nitrogen in paddy fields was measured precisely throughout Japan and their data, was summarized in which both nitrogen inflow and nitrogen outflow were 10 kg•N/ha to 60 kg•N/ha (**Fig. 2**). Paddy fields are complicated, and each shows a different value.

The amount of nitrogen flowing into paddy fields is small, about 10 kg•N/ha, if water used for irrigation is not polluted. However, paddy fields near cities that use polluted water showed high values of 60 kg•N/ha or so. Nitrogen outflow varied significantly with the methods used to control water and apply fertilizers, and was between 10 kg•N/ha and 60 kg•N/ha. A paddy field may take in 10 kg•N/ha and discharge 60 kg•N/ha, attributing contamination of 50 kg•N/ha. Another paddy field may intake 60 kg•N/ha and discharge 10 kg•N/ha, thus reducing 50 kg•N/ha. Some paddy fields cause pollution while others purify water.

Let's call those paddy fields that cause pollution "outflow-type paddy fields" and purifying fields "absorber-type paddy fields". Paddy fields of both types are discussed in detail.

Figure 3 plots nitrogen inflow (input) on the x-axis and nitrogen outflow (output) on the y-axis. Values measured in various regions of Japan are widely scattered but tend to show a proportional relationship and align near the 1:1 line. If nitrogen inflow increases, nitrogen outflow will increase. Paddy fields that consume a lot of water receive a lot of nitrogen and at the same time discharge a lot of nitrogen since they discharge a lot of water. Polder fields are of this type. Paddy fields that save water or use "circulation irrigation", on the other hand, take in and discharge small amounts of both water and nitrogen and are plotted near the origin in **Fig. 3**.

From the viewpoint of conserving water quality, the difference between nitrogen inflow and nitrogen outflow is important. The amount of nitrogen coming in is called "inflow load" while the amount of nitrogen going out is called "outflow load". When the inflow load of a paddy field is larger than its outflow load, the field reduces nitrogen, and it is thus an absorber-type paddy field. This type of field absorbs and removes nitrogen as water passes through it, i.e., it plays a purification role. However, if the outflow load of a field is larger than its inflow load, the field discharges nitrogen, and is thus an outflow-type paddy field. Points above the 1:1 line in **Fig. 3** show paddy fields in which the difference between outflow and inflow loads is positive, i.e., outflow-type fields. Points under the line are fields of negative difference or absorber-type fields. Absorber-type paddy fields include many fields near cities that are irrigated with polluted water. Outflow-type paddy fields include highly permeative fields on fans and plateaus and fields which take in abundant water.

As **Fig. 3** shows, most outflow-and-inflow-load differences are distributed within ±20 kg•N/ha from 0 kg•N/ha. The numbers of paddy fields of both types are half-and-half. How can we change an

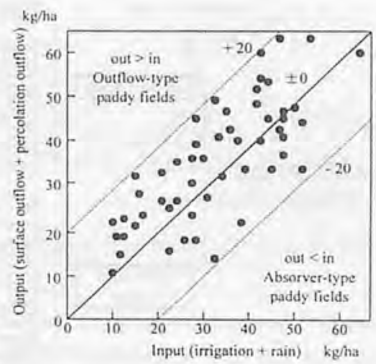

Fig. 3 Relation between nitrogen input and output in paddy fields.

outflow-type paddy field into an absorber-type field?

Methods for Preventing Nitrogen Discharge from Paddy Fields

There are four methods for preventing nitrogen discharge from paddy fields (**Fig. 4**).

First — Prevention of nitrogen outflow from the ground surface. Ponding water should not be drained immediately after initial application of fertilizers. In fields that are irrigated plot-to-plot, the amount of irrigation water should be minimized in order to reduce discharge from the terminal plots.

Second — Improved methods of fertilizer application. To minimize the fertilizer concentration in water covering the field surface, fertilizers should be applied to the plowed soil directly, or slow-release fertilizers should be used. Rice transplanters with fertilizer-applicator have recently been invented, which apply fertilizers to the plowed soil while transplanting rice seedlings, and reduce both fertilizer loss and application time. Slow-release fertilizer, which are coated, do not dissolve immediately.

Third — Prevention of over-percolation outflow. The amount of water percolating in the soil should be minimized. Puddling and soil compaction and dressing are effec-

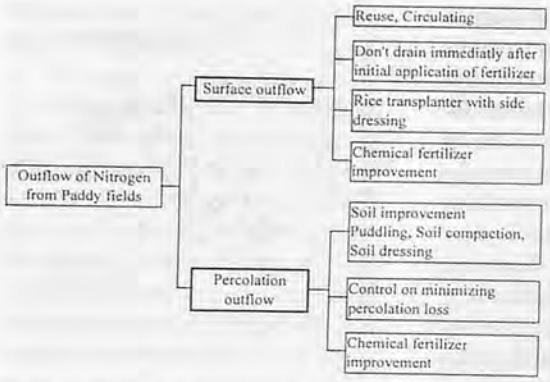

Fig. 4 Methods for preventing nitrogen discharge from paddy fields.

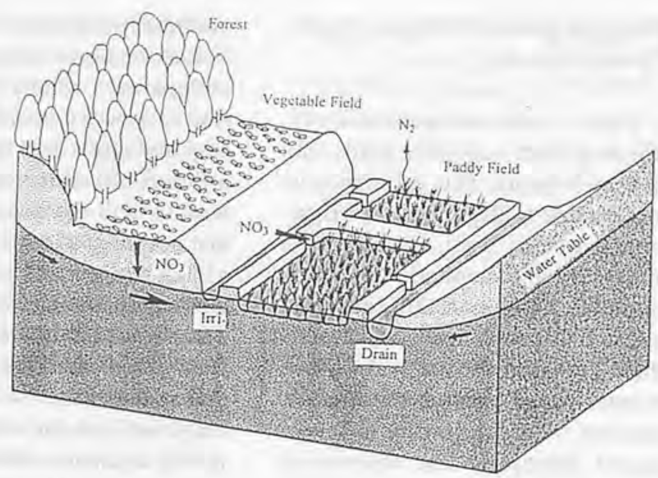

Fig. 5 Nitrogen flow from highland to lowland.

tive. When the surface soil is sandy or undispersed aggregate, puddling is not effective, and either soil compaction or dressing should be used. Soil dressing, however, is generally difficult if suitable dressing soil, such as alluvial soil or andesite, is not available near the field and transportation is costly. Soil compaction with plow sole layer and levees, which is relatively inexpensive, is usually suitable (Inoue and Tokunaga, 1995).

Fourth — Prevention of nitrogen discharge from a paddy field system. This regards all paddy fields in a district as one system. "Circulation irrigation", which reuses discharged water for irrigating downstream or other fields in the district, should be conducted. Since excessive use of water always invites a large amount of waste water and may cause outflow of fertilizers, it may be necessary to reduce the amount of irrigation water. However, as discussed in the previous section, paddy fields may be purifying polluted water, and simply large amounts of irrigation water may not be a problem. However, circulation irrigation, that returns the nitrogen which was once discharged to drainage canals back to fields, is effective not only for saving water but also for conserving water quality.

Outflow load may be significantly reduced by using these improved methods of water management, fertilizer application, and over-percolation prevention.

The point is that even unimproved or outflow-type paddy fields discharge only 30~40 kg•N/ha of nitrogen, while heavily fertilized vegetable fields may release 100 kg•N/ha or more. Japan has a large acreage of paddy fields and a land-use structure comprising forests, paddy fields, and vegetable fields. Nitrogen load generated on high lands is removed in downstream paddy fields. Such a natural topographic chain removes nitrogen (**Fig. 5**). This may be attributable to the low nitrate concentration of underground water in Japan. Paddy fields are earth-friendly agriculture.

Nitrogen Removal in Paddy Fields

Water for irrigating paddy fields is once stored there. A portion of the water penetrated gradually through plowed soil and plow sole layers and into groundwater. As water passes through soil, dead leaves and insects are removed at the surface, and pollutants not suitable for drinking water are eliminated in the soil, thus leaving the percolated water clean. Nitrogen, especially, is absorbed by rice plants or decomposed and released into the atmosphere.

Fertilizers are composed of nitrogen. Rice grows tall and robust by absorbing nitrogen applied as fertilizers. Nitrogen exists in paddy fields in the form of ammonia. Ammonia is once adsorbed in the clayey component of the plowed soil and gradually absorbed by rice plants. A portion of the ammonia is absorbed by aquatic plants and algae living in the surface water. Another portion is oxidized into nitrate by nitrifiers, microorganisms living in the surfaces of the water and soil. Nitrifiers obtain energy by oxidizing ammonia in the presence of oxygen. During day time, rice and other aqueous plants release oxygen produced by photosynthesis, and oxygen is generally supersaturated in surface water. This flow is called "nitrification". Nitrate, while passing through the plowed soil, is either absorbed by rice or deoxidized by denitrifiers living in the reduced layer of soil, which is oxygen free, and is released into the atmosphere. This flow is called "denitrification". Changes in form and flow of nitrogen are shown in **Fig. 6**.

Plants and nitrifiers compete for ammonia in surface water. Generally, the ability of plants to absorb ammonia is stronger than nitrification. Thus, ammonia applied as fertilizers is difficult to convert into nitrate. When both ammonia and nitrate exist, plants absorb ammonia first and start to use nitrate when

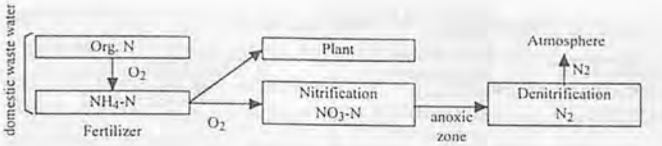

Fig. 6 Changes in form and flow of nitrogen in paddy fields.

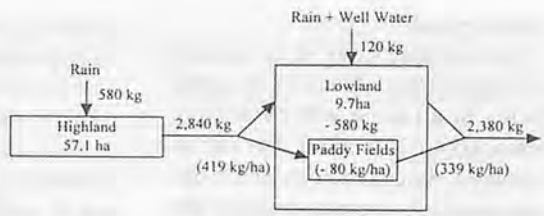

Fig. 7 Total yearly nitrogen flow from highland to lowland paddy fields in a small watershed.

ammonia has almost disappeared (Hata et al., 1987). Paddy fields are generally conditioned so that these systems function well, and nitrate or ammonia does not reach groundwater.

In what kinds of paddy fields does nitrate or ammonia reach groundwater? One is over-percolating paddy fields. Water flows into groundwater faster than nitrate is absorbed by plants or denitrified by denitrifiers (Tabuchi and Yamafuji, 1992). Another is fields in which groundwater level is too low to saturate the lower soil layer with water, causing unsaturated percolation similar to that in vegetable fields. These fields can be improved by land consolidation.

Paddy fields contain shallow water that allows the sunlight to reach the bottom and thus promotes growth of filamentous algae such as *spirogyra porticalis* on the substrate. Algae also become entangled with the underwater stems and leaves of rice and other plants, and increase in number as the plants grow and the area in contact with surface water expands. These algae catch floating substances and further enhance the water purification ability of paddy fields.

As dirty water is cleared by percolating through a layer of sand. Paddy fields act as a natural filter in the ecosystem and purify water.

Expected Nitrogen Removal in Paddy Fields

As discussed in the previous section, nitrogen is either absorbed by aquatic plants or changed into nitrogen gas by denitrification while passing through a paddy field, hence, purifying polluted water. The extent of each purifying action depends on the form of inflowing nitrogen, the amount of floating material, water depth, residence time, and amount of percolation. It is also affected by climatic conditions such as water temperature and intensity of solar radiation and varies with the season and even with the hour of the day (Hata and Ishikawa, 1996).

Paddy fields remove nitrogen in roughly two ways, i.e., purification in the water at the field surface and percolation of water through plant roots. Both systems work in most fields. However, lowland paddy fields, such as those in ravines, do not allow water percolation, and thus purification occurs only at the surface.

Nitrate Removal by Paddy Fields in Ravines

Water polluted by nitrate nitrogen is often waste water from vegetable fields or livestock farms. By irrigating paddy fields with such polluted water, denitrification at the soil surface and absorption by plants may be expected. Both surface-type and percolation-type purification are effective. There is an example that a paddy field in ravine uses and effectively purifies water polluted with nitrate.

Paddy fields in ravines are located downstream which farmers have constructed at the bottoms of valleys and creeks to collect water from higher lands. In other words, these fields are located in low lands where rain water has percolated through plateaus. This is a typical topography of the Kanto Area in Japan. The Kanto Area covers the area extending for a radius of 100 km from Metropolitan Tokyo. Farm villages in this area grow vegetables or livestock on high lands and use lower lands as paddy fields. Since upland vegetable fields use a lot of fertilizer, the water percolating into the soil contains high concentrations of nitrate nitrogen. Water with 5 *mg/l* or 10 *mg/l* may come out onto a ravine and be introduced to paddy fields. A value as high as 34 *mg/l* had been observed (Kuroda et al., 1996). Normally functioning paddy fields can remove a lot of nitrate from this water. This purification ability, which was precisely researched, is illustrated in **Fig. 7** (Tabuchi and Kuroda, 1991).

The district that was researched comprises 9.7 ha of lowland and 57.1 ha of highland, of which 33.7 ha is forest and 20.7 ha is vegetable fields. The amount of nitrogen flowing from the highland into the paddy fields was 2 840 kg annually. After passing through the paddy fields, this was reduced to 2 380 kg: a difference of 580 kg. Each hectare of the paddy field received 419 kg and discharged 339 kg, a reduction of 80 kg, of which 88% was removed during the irrigation period.

Eighty kilograms per ha is a large amount. Since 100 kg per ha of nitrogen fertilizer is generally applied to paddy fields, a comparable amount was removed. In fact, farmers do not apply fertilizer to these paddy fields because it may invite lodging of the rice plants —

which is bad.

In a similar study in an animal-raising district, reduction by paddy fields in a ravine was even more remarkable: 326 kg/ha. The nitrate nitrogen concentrations in six up-stream creeks were as high as 10~30 *mg/l* (Tabuchi, 1986). Water with concentrations of over 50 *mg/l* percolated near storage ponds by pig barns (Shimura and Tabuchi, 1996). The outflow load of nitrogen in this region corresponded to the population of pigs.

Increase in Devastated Paddy Fields in Ravines

Paddy fields in ravines are often too small to use machines and are not connected with roads wide enough for large vehicles to pass. From generation to generation, farmers have been constructing and maintaining such paddy fields to secure true happiness in their lives. Today, Japanese farmers have to irrigate these fields with ground-water polluted with nitrate. They are forced to use such polluted water for their carefully grown rice. They do not need to pay for fertilizers, but they should not feel good. Moreover, the government of Japan demands that farmers reduce rice cultivation. Paddy fields in ravines are thus objects of the set-aside policy. No land consolidation works have been conducted in these fields. Thus these farmers have suffered two-fold and three-fold. They may not be able to tolerate any more and paddy fields in ravines may be increasingly fallowed or devastated. Paddy fields that spontaneously preserve water quality are being abandoned. Devastation of such fields and their conversion to dumping grounds must be somehow arrested.

Abandoned and devastated paddy fields lose their capacity for flood control. As a result, they cannot cultivate water resources, and this leads to the deterioration of water quality and thus pollution of groundwater and lakes. These things rebound against the cities (**Fig. 8**). We should recognize and conserve paddy fields in ravines as areas necessary for preserving water quality. We should also thank the farmers and conduct land consolidation works from the very beginning.

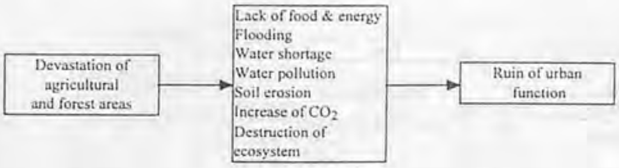

Fig. 8 Influence of devastation of agricultural and forest areas on urban function.

Utilization of Water-purification Ability of Paddy Fields

Unlike vegetable fields, paddy fields are filled with water. The soil in paddy fields is in a reduced state, and applied ammonia is difficult to convert to nitrate. Ammonia is adsorbed by soil or absorbed and utilized by rice plants. Since high concentrations of ammonia are dissolved in paddy field water immediately after application of fertilizers, drainage of ponded water or excess permeation may invite an outflow from the system. Water management by people and fertilizer application greatly effect nitrogen movement.

Acreage of paddy fields beside forest areas is important for conserving water quality. The ability of paddy fields for removing nitrogen should be effectively utilized. Of course, water should not contain heavy metals or other toxic substances which may destroy agriculture. Toxic substances generally do not exist in rural areas, and these substances must not be brought into agricultural districts from cities and dumped.

Methods for Maximizing the Ability of Paddy Fields to Remove Nitrogen

Three methods exist for utilizing the ability of paddy fields to remove nitrogen.

The first pays no regard to yield. As has been mentioned, paddy fields and wetlands can remove 100 kg of nitrogen per ha annually. However, such unproductive utilization of fields does not consider farmers' feelings and is not practical.

The second method is to utilize fallow paddy fields. In Japan today, more and more paddy fields in ravine are fallowed and devastated. The acreage of irrigated fields is continually decreasing. Farmers may receive economical benefits by irrigating these fallow fields and cultivating aquatic flowering plants such as iris and other useful plants such as cress and mat rush. Since fields are ponded, farmers can return to rice cultivation any time they want. Nitrogen removal of 800 kg/ha is actually reported in fallow fields in ravines irrigated with water of high nitrate concentration from vegetable fields (Tabuchi et al., 1993). Nitrate removal increases in proportion to the nitrate concentration (Tabuchi et al., 1987). Projects in which municipal bodies buy fallow fields from farmers to create cooperative farms or natural parks are also being investigated. However, in Japan, this is a last resort for paddy fields in ravines, which are victims of the set-aside policy.

The third method is to utilize well-constructed paddy fields (Ishikawa et al., 1992). The basic conditions for multi-purpose use of paddy fields are nonrestricted control of both field water and groundwater levels and have the rights of farmers to select crops anytime. Leaching water from adjacent fields is suppressed by walls of impermeable soil layers surrounding them. These fields, which are called "well-constructed fields", are ideal and have united structures. They are obviously of the absorber type.

Water Purification Experiment Using Well-constructed Fields

Characteristics of the Experiment

A water purification experiment using underdrains was conducted in a large plot of approximately 1.7 ha along Lake Inbanuma, Sakura City, Chiba Prefecture, Japan. Irrigation water was taken from Lake Inbanuma, in which eutrophication had recently advanced due to inflow of city sewage. Principal water pipes were installed under municipal roads, and they diverge into smaller pipes under branch roads to irrigate the plot. Underdrains were installed in the plot each 10 meters 1.0 to 1.2 meters deep with a fall of 1/500. Permeation below the drain level or to the levee was almost 0. An auto-irrigator powered with a solar battery was also installed. This made it possible to maintain the levels of irrigation water and groundwater automatically. It was a labor-saving device that could supply appropriate amounts of water. The field could be irrigated from both ground surface and underground. However, the experiment was conducted with surface irrigation only.

Ten to 20 mm/day of water was discharged through the underdrains during a rice-cultivating period. Water passed by gravity through a soil layer from the surface to the underdrain level. The underdrains, which are usually closed during cultivation periods, were opened in order to increase the yield and purify the water from the lake by artificially causing percolation. However, they were closed for one week after fertilizers had been applied to prevent outflow of fertilizers. In that case, the amount of water lost by evaporation was resupplied. Fertilizers were applied together with irrigation water, in which fertilizers were dissolved at a specified concentration. The soil was a uniform sandy soil.

Water Balance During Irrigation Period (110 days)

The total water inflow was 2 241 mm, i.e., 1 970 mm irrigation and 271 mm precipitation. The total water outflow was 2 320 mm, of which 2 000 mm was discharged through underdrains and 320 mm by evaporation. The inflow and outflow were almost equal. The outflow was slightly larger, 79 mm, indicating little permeation below the underdrain level or to the levee and a reduction of water contained the soil at the end of the irrigation period.

Measurements of Water Quality

Throughout the irrigation period, the T-N concentration in water flowing out through the underdrains remained stable, and lower than that in the irrigation water. Even when the irrigated nitrogen concentration increased, the outflow concentration remained stable and low. The simple mean concentrations were 1.7 *mg/l* in irrigation water and 1.1 *mg/l* in outflow water.

Fig. 9 shows the nitrogen balance of the field. Some 33 kg•N/ha of nitrogen was introduced with the irrigation water, 2 kg•N/ha with rain, and 51 kg•N/ha from fertilizers. Some 81 kg•N/ha of nitrogen was absorbed by rice, and 19 kg•N/ha discharged from underdrains. The amount applied as fertilizers was less than the value absorbed by rice, making a total difference of

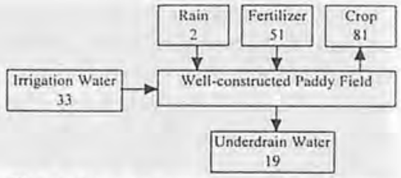

Fig. 9 Nitrogen input and output in well-constructed paddy field (kg/ha).

14 kg•N/ha. The inflow load from rain and irrigation water combined was 35 kg•N/ha, and the outflow load was 19 kg•N/ha. The difference between the outflow load and the inflow load was - 16 kg•N/ha. Reduction of nitrogen by permeation was 46%. This experiment demonstrated that nitrogen may be reduced by introducing eutrophic lake water into paddy fields and utilizing underdrains.

However, metals such as Fe were eluviated from the soil through the underdrains. The total inflow load of iron was 12 kg/ha while its outflow load was 303 kg/ha. Utilization of underdrain water containing so much iron is given below.

Yield

In one cropping season a field yielded 5 460 kg/ha of rice, an increase of 300 kg/ha over the previous year. Although the values cannot be easily compared because of different weather conditions, it can be concluded that this method does not reduce yield since the mean yield in the entire Sakura district was 4 920 kg/ha, an increase of 260 kg/ha from the previous year. Water purification and increase in yield may be expected by opening underdrains during the irrigation period.

Utilization of Underdrain Water

A good farmer in Esashi City, Iwate Prefecture, Japan, reported that the conception rate of his cows rose significantly after he started to utilize water discharged through underdrains.

Underdrain water contains a lot of iron. A cow drinks 30~40 *liters* of water a day. The farmer thought that cows as well as people need iron and, therefore, started to utilize underdrain water. The cows that drank this water showed significantly higher conception rates. Almost all services were successful. The farmer, who had initially raised eight reproductive cows, obtained eight calves each year.

Water directly discharged from surface of paddy fields may contain agricultural chemicals that have adverse effects. Underdrain water, on the other hand, has been percolated by the soil and is different from water at the surface of the paddy fields. It is safe for cows and is free. No labor is necessary to supply it.

Paddy fields are indeed a wonderful structure for soil.

Conclusion

To our emphasis on environmental conservation, some people may respond "Let's convert farmlands into forest." Indeed, such an idea may conserve the environment, but people need to obtain food from farmlands. It is embarrassing to solve this problem by importing food from other nations. It is difficult, both economically and morally, to continue importing large amounts of food thus forcing other nations to solve the most difficult problem of conducting environment-friendly agriculture that both produces food and conserves the environment. We should produce food in a stable manner within our nation and, at the same time, maintain agricultural land that is environment-friendly. Only farmland that supports food consumption in the region can conserve water, greenery, soil and human health. Paddy fields have the qualities necessary for such ideal farmland. Paddy fields foundations should be urgently and immediately improved and converted into well-constructed fields. Farming methods that are appropriate for each region and which produce constant yields from paddy fields even with reduced amounts of agricultural chemicals and fertilizers should be established.

There is not a global excess of food. People starve to death in developing countries due to debts that inhibits food importation and unbalanced food distribution. People in nations with advanced economies tend to forget that they also belong to nature and seek only to gratify their own desires, even going against nature.

People can live on this earth only because of plant products. We should recognize that we are heterotroph and get out of the narrow perception that a person who farms is a producer and one who eats without farming is a consumer. We should honestly consider how people should live in the global ecosystem, i.e., in the cycle of organic substances. People should recognize that if people continue being arrogant, seeking only economic development and destroying this permanent eco-system, they will also destroy their future.

The ecosystem comprises producers (plants, which produce organic substances from inorganic substances), consumers (organisms that live by consuming the organic substances produced by producers), reducers (microorganisms that convert organic substances of dead producers and consumers into inorganic substances), and factors other than organisms (sun, atmosphere, water, soil, etc.). These four factors are interrelated. Human existence is based on this relationship. People should not be arrogant, they should not seek only to gratify their desires, and they should consider the effects of their action upon organisms other than human being.

People will perish if they do not stop actions that destroy or pollute the environment or if they do not change the present international relationships and agriculture which value economic development over ecology.

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(Continued on page 55)

Mechanized Harvesting of Palm Fruits

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Abstract

A comparison of working times between manual and mechanized harvesting of palm fruits is described. Tests were carried out in Malaysia and showed a great reduction in working times (58%) relative to manual harvest.

Introduction

The main objectives of this research were to: i) improve the quality of palm fruits; ii) reduce working time; iii) reduce harvest loss; and iv) improve working condition in terms of safety and comfort for the harvesters.

The study was performed due to a competition proposed by the Chamber of Commerce, Industry and Agriculture of Cuneo (Italy), regarding the design and construction of a machine for harvesting palm fruits (*Elacis guineensis*), that is produced mainly in Malaysia (56% of world production) (**Fig. 1**). This graph shows the growth of palm oil production between 1979 and 1992. **Fig. 2** compares the performance of 12 farm products as source of rich substances showing that palm fruits are the richest source. On the other hand, **Fig. 3** also compares the performance of 10 farm products as source of vegetable with palm nut and palm being the richest source.

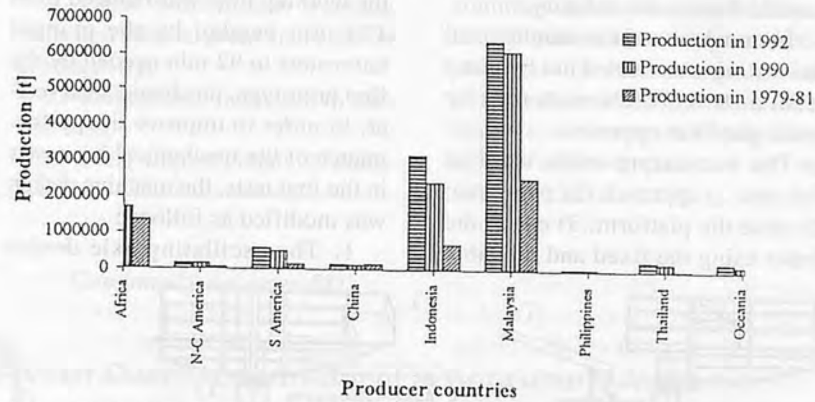

Fig. 1 Palm production: world distribution during the years (source: FAO).

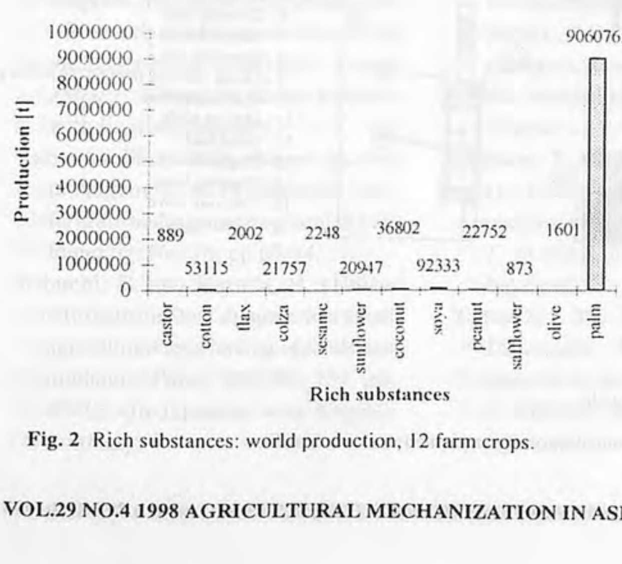

Fig. 2 Rich substances: world production, 12 farm crops.

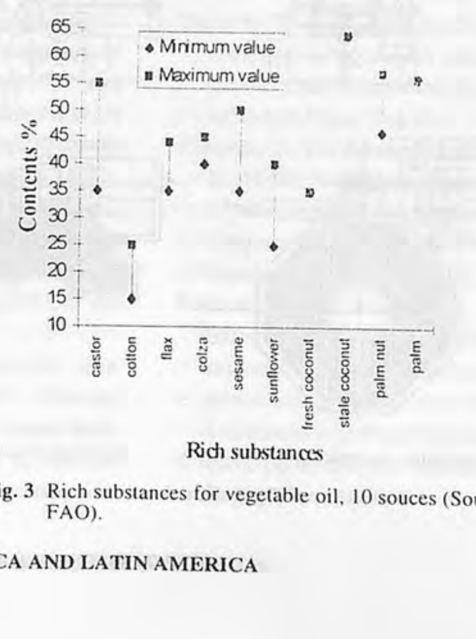

Fig. 3 Rich substances for vegetable oil, 10 souces (Source: FAO).

Harvesting Speed and Efficiency

The tests were performed by comparing manual harvesting and mechanized harvesting using two prototypes of mechanical harvesters: one made by OMARV (Savigliano, Cuneo, Italy) and another built by the same factory with C.N.R. (Institute for Agricultural Mechanization, Torino, Italy), in 1989 and in 1991, respectively. In comparison, manual harvesting was undertaken by team of operating units (OUs); the first team that cut off leaves and fruits, with the help of a pole, and heaped them near the tree. A second team of two OUs picked the fruits, along the row of trees, and transported them to the headland using a tractor and a trailer. A third team of OUs loaded the picked palm fruits in a lorry and hauled them to the refinery.

In comparison, the mechanized harvesting was carried out by just a team of two OUs: a tractor driver and a platform operator.

The harvesting steps were as follows: 1) approach the palm tree; 2) raise the platform; 3) cut of the fruits using the fixed and movable blades at the top of the telescopic arm; 4) lower the fruit-laden platform; 5) approach the next palm tree and repeat steps 1 to 4; 6) unload the fruits unto the machine's container; and 7) repeat steps 1 to 6 to harvest the fruits in the next palm tree.

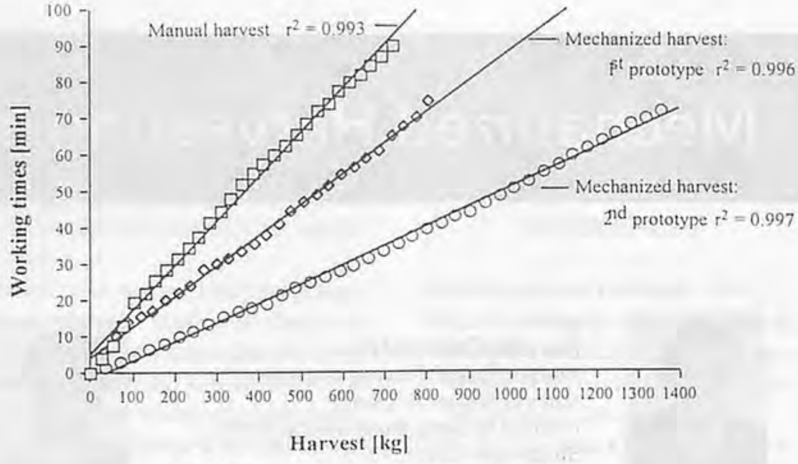

Fig. 4 Comparative length of time to harvest.

The graph in **Fig. 4** shows that, the working time was reduced from 125 min needed by the manual harvesters to 92 min needed by the first prototype, mechanical harvester. In order to improve the performance of the mechanical harvester in the first tests, the machine design was modified as follows:

1. The oscillating axle device was revised in order to reduce soil compaction and to reduce the angle of inclination when the machine passes through depressed areas, holes and other obstacles;
2. The hydraulic system was improved to reduce the time for raising and lowering the platform;
3. Manual controls were installed on the platform to allow disengaging by the automatic controls, to follow the tree-trunk during the raising and lowering of the platform;
4. A pneumatic tool outfit (patent CNR n° TO/91000184 dated 91/03/14) was used, also being

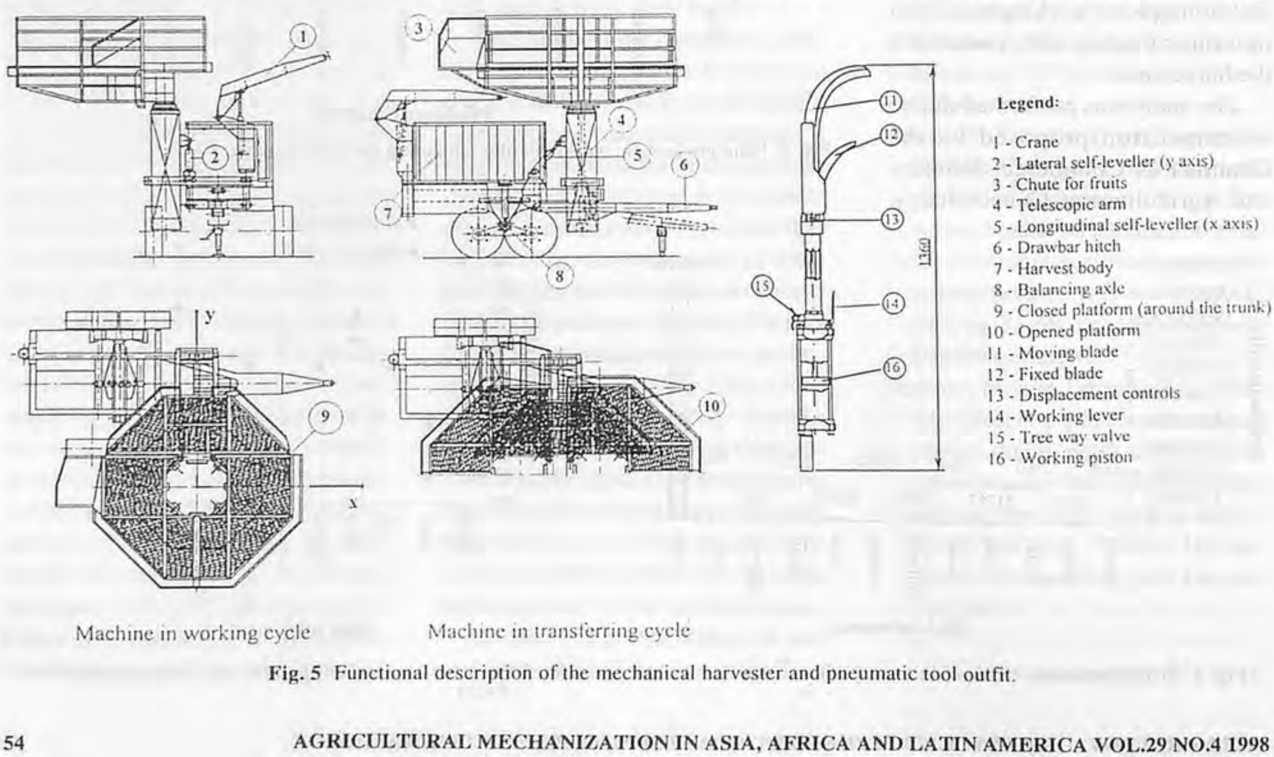

Fig. 5 Functional description of the mechanical harvester and pneumatic tool outfit.

made available to the same firm (OMARV)) to cut off leaves and fruits (**Fig. 5**);

5. A compressed air system hydraulically driven was installed to activate the tool;

6. A body jointed to the frame was used to avoid locking to the same frame;

7. A chute to unload the fruits from platform to body of machine was developed; and

8. A suitable crane necessary for full body unloading of harvested fruits unto the machine container was developed.

During the construction of the second prototype of the mechanical harvester, remarkable importance was given to safety in order to safeguard the operator when harvesting very tall palm trees.

In order to avoid any loss in stability, with its consequent overturning, it was made an automatic control of the platform was made vertical, by immediate and accurate longitudinal and transversal corrections. This system (**Fig. 5**) operates by means of two control sensors (x and y-axis) with pendular oscillation damping.

The use of the second prototype of mechanized harvesting completed the same job in 52.5 min or 58% time reduction vs. the manual harvester. Furthermore, during harvest, the fruit loss values were 3.65%, for the manual operation, and only 0.29% with the mechanized operation, or a reduction of 92%.

Conclusions

The introduction of mechanized harvesting, in the plantation where the tests were carried out, produced the following results:

1. Improvement of harvest quality, as the operator can go near the palm's (15-18 metres) fruits and choose the matured ones;

2. Great reduction in working time and thus a great increase in productivity;

3. Remarkable reduction in harvest loss;

4. Clear improvement of safety and comfort for the harvester during the operation.

Fig. 6 The mechanical harvester in action.

It should be noted that this agricultural mechanization, in the socio-economic reality of these countries, where the cost of labour is negligible and an increase of the productivity causes more unemployment, could be introduced by degrees, accompanied by a desirable social development. ■■

(Continued from page 52)

Practical Approach to Water Quality Improvement in Agricultural Areas

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Cost Analysis Model for Crop Production Machinery System

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Abstract

The success of many farm-level production systems depends on wise selection of machinery systems. The main aim of tractor and machinery selection studies is to complete a certain field operation during a specified time and at minimum cost. The number of crops in a rotation, different land size for different crops in crop operation, and the use of the same implement with different crops complicate the selection of machinery. The Crop Production Machinery System (CPMS) model was developed at Michigan State University, USA to predict the machinery requirements and to determine the cost of production. Three crops, five implements and one tractor were used on a 242.3 ha farm to demonstrate cost analysis. There was a savings of $631.42 per crop if the field cultivator was used in a multiple crops operation rather than for a single cropping such as field beans alone. A comparison for the tractor and machinery costs between a single cropping farm and the same crops in a crop rotation shows a savings of $5 672.00, $5 262.64 and $4 216.21 for corn, field beans, and wheat, respectively, when these crops were produced in a multiple crop farm. This example demonstrate that more crops in a rotation will increase machinery and tractor utilization.

Introduction

The application of machines to agricultural production has been one of the outstanding developments in agriculture. Machinery contributes a major capital input cost in most farm businesses. Many factors are involved in the process of equipping a modern farm for field operations. Among the most significant factors is economics. The economics of field equipment selection is a complex problem that has some unique characteristics compared to other industries. Agricultural production is seasonal, leaving machines standing idle most of the time. There is a need for timely operations in agricultural production because of the seasonal requirements of the crops.

The aim of this paper is to describe the machinery cost analysis model of the Crop Production Machinery System (CPMS) model. The objective is to develop the machinery cost analysis model to evaluate machinery costs after a complete set of implements and tractors is selected from the machinery selection model. The machinery cost analysis must be able to evaluate machinery costs when: (a) the use of machinery is shared in several enterprises; (b) the same machinery is used under different conditions (e.g., speed, depth, field efficiency and tractive efficiency); and (c) machinery costs are compared for different situations such as farm size and production practices.

The Crop Production Machinery System Model

The Crop Production Machinery System model developed at Michigan State University is a computer interactive model developed based on the concept of expert systems which allows the user to interact with the program. The computer program consists of the Machinery Selection Model and the Machinery Cost Analysis Model. The Machinery Selection Model will be used to predict the size of tractors and implements required to complete the farm operation during a specified duration of time and to determine the compatibility of tractors and implements by properly matching the available tractor power. The Machinery Cost Analysis Model will be used to estimate the cost for the tractors and implements selected in the Machinery Selection Model.

After the scheduling of all operations is completed by the CPMS model, the total annual cost of owning and operating the complete set of the machines will be determined. The analysis consists of determining the costs for; (a) each implement used per crop; (b) each implement used for all crops; (c) all implements used per tractor; (d) all implements and tractors used per crop; and (e) total implement and tractor costs for all crop operations.

Cost Analysis

The cost analysis by the CPMS program constitutes machinery cost. Machinery costs are the implement's and tractor's fixed and variable costs. The capital consumption and taxes, insurance and shelter costs are the fixed costs, which remain relatively constant regardless of use, but are dependent on calendar-year time (Hunt, 1983). The repair and maintenance, oil, fuel and operator's labor costs are proportional to the machine use. The repair and maintenance, capital consumption, and taxes, insurance and shelter costs are the costs being shared by other crops in a crop rotation. The shared cost for each implement is calculated based on the proportion of time used by each crop to the total field time used by all the crops.

The costs equations used in the CPMS model are obtained from the ASAE Standards (ASAE, 1990). Simplified equations derived from the ASAE Standards by Kepner et al. (1978) and Hunt (1983) are also used.

Capital Cost

Simple interest on the average investment over the life of the machine can be added to the annual depreciation to estimate the yearly capital costs of ownership. A method which includes the time value of money and which makes use of a capital recovery factor (CRF) was used for determining the capital costs of ownership (CC). The mathematical relationships used in calculating capital cost were obtained from the ASAE Standards (1990), Hunt (1983) and Barry et al. (1988).

$$S\$ = 0.1 \times PPM$$

$$CC = (PPM - S\$) \times CRF + S\$ \times I$$

$$CRF = \frac{I(1 + I)^L}{(1 + I)^L - 1}$$

where
I = interest, decimal
L = life of the investment in years (predicted life of implement)
PPM = machinery purchase price, \$
S\$ = Salvage value, \$

Taxes, Insurance and Shelter Cost

Taxes, insurance and shelter costs (TIS) make use of the implement and tractor remaining value (RV). The equations below are obtained from the ASAE Standards (1990) and Kepner et al. (1978).

The remaining value for a tractor (RVNT) at the end of the nth year is given as:

$$RVNT = LPM \times 0.68 \times 0.92^n$$

The remaining value for a tractor at the end of the (n-1)th year (RVMT) is given as:

$$RVMT = LPM \times 0.68 \times 0.92^{n-1}$$

Thus, the taxes, insurance and shelter cost (TIST) for a tractor at the end of the year is given as:

$$TIST = 0.04 \times \frac{RVMT + RVNT}{2}$$

The remaining value for an implement at the end of the nth year (RVNM) is given as:

$$RVNM = LPM \times 0.60 \times 0.89^n$$

The remaining value for an implement at the end of the (n-1)th year (RVMM) is given as:

$$RVMM = LPM \times 0.60 \times 0.89^{n-1}$$

Thus, the taxes, insurance and shelter cost for an implement at the end of the nth year (TISM) is given as:

$$TISM = 0.04 \times \frac{RVMM + RVNM}{2}$$

where LPM = machinery list price.

Repair and Maintenance Cost

Expenditures due to part wear failure, accidents, and natural deterioration are necessary to keep the tractor and implement operational. The size of a machine, as reflected by its price, and the amount of use are factors affecting these costs. Total accumulated repair and maintenance costs (TAR) at a typical field speed can be determined using the repair and maintenance factors (RF1 and RF2) and the accumulated hours of machine use (USE). The accumulated machine field time (FT) is based on the age and the annual field time. The values for the RF1 and RF2 for the tractors and implements were obtained from ASAE EP 391.1 (ASAE, 1990).

The accumulated hours of use for a tractor or implement at the end of the nth year (USEN) are given as:

$$USEN = FT \times n$$

The accumulated hours of use for a tractor or implement at the end of (n–1)th year (USEM) are given as:

$$USEM = FT \times (n-1)$$

The total accumulated repair and maintenance cost for a tractor or implement at the end of the nth year (TARN) is given as:

$$TARN = LPM \times RF1 \times \left(\frac{USEN}{1000}\right)^{RF2}$$

The total accumulated repair and maintenance cost for a tractor or implement at the end of the (n–1)th year (TARM) is given as:

$$TARM = LPM \times RF1 \times \left(\frac{USEM}{1000}\right)^{RF2}$$

The total repair and maintenance cost for a tractor or implement (RMN) is given as:

$$RMN = TARN - TARM$$

Fuel Cost

Typical farm tractor engines above 20% load are modelled by the equations below, and typical fuel consumption (FCN) is given in ℓ/kW.h (ASAE, 1990).

The diesel fuel consumption of a tractor operating implement is given as:

$$FCN = 2.64 \times \frac{EPTOP}{APTOP} + 3.91 - 0.203\sqrt{738 \times \frac{EPTOP}{APTOP} + 173}$$

The fuel use and fuel cost are given as:

$$FU = FCN \times FT \times EPTOP$$

$$FC = FU \times F$$

where
EPTOP = Equivalent power take-off
APTOP = Available power take-off
FU = Fuel use for one operation and one crop, ℓ
FC = Fuel cost for one operation and one crop, $
F = Fuel price, $/ℓ

Oil Cost

Consumption is in ℓ/h where the rated engine power is assumed to be equivalent to maximum available power from the PTO (APTOP) (ASAE, 1990).

The oil consumption of a tractor operating an implement is given as:

$$OCN = 0.00059 \times APTOP + 0.02169$$

The oil use and oil cost are given as:

$$OU = OCN \times FT$$
$$OC = OU \times O$$

where
OCN = oil consumption, ℓ/h
OU = oil use for one operation and for one crop, ℓ
OC = oil cost for one operation and for one crop, $
O = oil price, $/ℓ

Labor Cost

Labor cost is computed based on recommendation for local conditions which involve one operator for each tractor. Labor is charged at an hourly wage rate. The field time was increased by 10% to allow for travel time between fields.

$$LC = 1.1 \times FT \times L\$$$

where
LC = labor cost for one operation and for one crop, $
L$ = labor rate, $/h

Machinery Cost

The equation below expresses the approximate annual cost for an implement in constant dollars.

$$AC = CC + TIS + RMN + LC + OC + FC + TC$$

where
AC = annual cost of implements, $/yr
TC = annual tractor cost attributed to this implement, $
Other terms were defined earlier.

Tractor Cost

The labor cost, fuel cost and oil cost are the actual operating costs directly related to the field time used by an implement, and are included in the annual implement operating cost calculations. The repair and maintenance cost, capital consumption cost, and taxes, insurance and shelter cost for each tractor and for each implement are the costs being shared by other crops in a rotation. The shared costs for each implement and each tractor are calculated based on the proportion of time used by each crop to the cumulative field time used by all the crops. The total annual cost for one tractor (TC_o) is:

$$TC_o = RMT + CC + TIS$$

For a single crop farm, the total tractor and machinery cost (AC) is:

$$AC = \Sigma MC + \Sigma TC$$

MC (for each implement)
$= LC + FC + OC + RMI + CC + TIS$

TC_o (for each tractor)
$= RMT + CCT + TIST$

where
RMT = Tractor repair and maintenance cost, $
RMI = Implement repair and maintenance cost, $
CCT = Tractor capital cost of ownership, $
TIST = Tractor taxes, insurance and shelter, $
Other terms were defined earlier.

For multiple crop farms, the total tractor and machinery cost will be:

$$AC = \Sigma MC_A + \Sigma MC_S + \Sigma TC_S$$

MC_A (for each implement)
$= LC + FC + OC$

MC_S (for each implement)
$= (RMI + CC + TIS) \times FT/TFT$

MC_S (for each tractor)
$= (RMT + CCT + TIST) \times FTT/TFTT$

where
FT = Implement field time for each implement used by each crop
TFT = Implement field time for each implement used by all crops
FTT = Total implement field time used by each crop for each tractor
TFTT = Total implement field time used by all crops for each tractor

Corn-Corn-Field Beans-Wheat (C-C-FB-W) Farm

One sample farm is given here. This farm is a 242.3 ha in size and located in East Lansing, Michigan, USA. Three crops, five implements and one tractor are considered in this

Table 1. Total Implement Costs for Each Implement for All Crops in a Rotation

Item	Chisel	F.cult	Planter	Drill	Total
Crop	c,c&fb	c,c,w&fb	c,c&fb	w	
Price	1 820.00	2 750.00	12 840.00	4 775.00	
Age(yr)	3	3	3	3	
Life(yr)	10	10	10	10	
EPTOP(kW)	38.24	44.76	37.04	26.88	
Time(h)	143.69	130.08	103.77	58.65	436.19
Fuel(ℓ)	2 431.23	2 436.40	1 725.70	844.56	7 437.89
Fuel(ℓ/h)	16.92	18.73	16.63	14.40	
Costs					
Labor($)	1 106.38	1 001.59	799.01	451.64	3 358.61
Fuel($)	510.68	511.64	362.50	177.31	1 562.13
Oil($)	8.18	7.40	5.91	3.34	24.82
R&m($)	131.99	136.97	620.09	69.59	958.65
Capital($)	311.74	471.04	2 199.31	817.89	3 799.97
Tis($)	4 087	61.75	288.34	107.23	498.19
Total($)	2 109.84	2 190.40	4 275.15	1 627.00	10 202.38

Table 2. Implement Cost Analysis for Each Crop Assumed as a Single Crop Operation

Item	Chisel	F.cult	F.cult	Planter	Drill
Crop	Ea.Crop	Ea.Crop		Ea.Crop	
	c,fb	c,w	fb	c,fb	w
Price($)	1 820.00	2 750.00	2 750.00	12 840.00	4 775.00
Age(yr)	3	3	3	3	3
Life(yr)	10	10	10	10	10
EPTOP(kW)	38.24	44.76	44.76	37.04	26.88
Time(h)	47.90	26.02	52.03	34.59	58.65
Fuel(ℓ)	810.47	487.35	974.52	575.23	844.56
Fuel(ℓ/h)	16.92	18.73	18.73	16.63	14.40
Costs					
Labor($)	368.79	200.32	400.63	266.34	451.64
Fuel($)	170.23	102.33	204.66	120.83	177.31
Oil($)	2.73	1.48	2.96	1.97	3.34
R&m($)	28.35	14.39	37.98	61.73	69.59
Capital($)	311.74	471.04	471.04	2 199.31	817.89
Tis($)	40.87	61.75	61.75	288.34	107.23
Total($)	922.71	851.31	1 179.02	2 938.51	1 627.00

sample farms. The three crops are corn, field beans and wheat. The five implements to be used are a chisel plow, disk harrow, field cultivator, row crop planter and grain drill.

The CPMS model determined the size of the implement, the power requirement and field time required to complete the farm operation for each implement selected. The commercial sizes selected for the chisel plow, field cultivator, row crop planter, and grain drill are 2.13, 3.05, 4.57 and 2.31 m, respectively. The power requirements for the chisel plow, field cultivator, row crop planter, and grain drill were calculated to be 47.8, 55.95, 46.30, and 33.60 kW, respectively. The tractor size selected was a 59.7 kW tractor that was able to pull all of the selected implements. The selected chisel plow, field cultivator, row crop planter, and grain drill required 47.90, 26.02, 34.59, and 58.55 hours, respectively, to complete the farm operation.

Analysis of Costs

(a) *Machinery costs* — **Table 1** shows the implement cost analysis for each implement used by a number of crops in a C-C-FB-W rotation. The chisel plow was used for corn (after wheat), corn (after corn) and field beans. The total chisel plow machinery cost used for all these crops was calculated to be $2 109.84. The field cultivator was used for all crops in this rotation. The total field cultivator machinery cost for all crops was calculated to be $2 190.40. The row crop planter was used for corn (after wheat), corn (after corn) and field beans and the total planter machinery cost was calculated to be $4 275.15. The grain drill was used only by wheat with a total machinery cost of $1 627.00. **Table 2** shows the implement cost analysis for using the chisel plow, field cultivator, row crop planter and grain drill for each crop assumed as a single crop operation. The total machinery costs for each crop for the chisel plow, row crop planter and grain drill were calculated to be $922.71, $2 938.51 and $1 627.00, respectively. The total field cultivator machinery costs for corn (after wheat), corn (after corn), and wheat, and for field beans were calculated to be $851.31 and $1 179.02, respectively.

The above machinery costs for each implement were compared with the same implement when used for all crops in the rotation. The above comparisons show savings of $219.43 per crop, $303,71 per crop, and $1 513.46 per crop for the chisel plow, field cultivator, and row crop planter. It shows a savings of $631.42 per crop if the field cultivator was used in a multiple crops operation rather than for field beans alone. This example demonstrates the utilization of the implements with the multiple crops for a 242.3-ha farm compared with single cropping for a 60.7-ha farm.

(b) *Tractor cost* — **Table 3** shows the tractor cost analysis used for all crops in a rotation. The total tractor cost was calculated to be $5275.64. **Table 4** shows the tractor cost analysis for the individual crop operations assumed as a single crop operation. The costs of using the tractor for the corn, field beans and wheat were calculated to be $ 4 838.35, $4 853.84 and $4 827.08, respectively. The above tractor costs for each crop assumed as a single crop operation were compared with

Table 3. Total Tractor Costs for All Crops in a Rotation

Item	Tract I
Crop	c,c,fb & w
Age(yr)	3
Life(yr)	15
Price($)	28 000.00
Time(h)	436.18
R&m($)	466.13
Capital consumption($)	4 035.97
Taxes, ins & shelter($)	773.54
Total	5 275.64

Table 4. Tractor Cost Analysis for Each Tractor for Each Crop Assumed as a Single Crop Operation

Item	Tract I	Tract I	Tract I
Crop	Ea.Crop		
	c	fb	w
Age(yr)	3	3	3
Life(yr)	15	15	15
Price($)	28 000.00	28 000.00	28 000.00
Time(h)	108.50	134.51	84.67
R&m($)	28.84	44.33	17.56
Capital($)	4 035.97	4 035.97	4 035.97
Tis($)	773.54	773.54	773.54
Tital($)	4 838.35	4 853.84	4 827.08

Table 5. Summary for Machinery and Tractor Cost for Single Cropping Using a One-Tractor Operation

Item	Corn	F.beans	Wheat
Area(ha)	60.7	60.7	60.7
Total field time(h)	108.50	134.51	84.67
Machinery cost($)	4 712.53	5 040.24	2 478.30
Tractor cost($)	4 838.35	4 853.84	4 827.08
Total M&T cost($)	9 550.88	9 894.08	7 305.38
Cost per hectare($/ha)	157.35	163.00	120.35
Cost per hour($/h)	88.03	73.55	86.28

Table 6. Summary for Machinery and Tractor Costs for Each Crop in a C-C-FB-W Crop Rotation

Item	Corn (after wheat)	Corn (after corn)	F.beans	Wheat	Total
Area(ha)	60.7	60.7	60.7	60.7	242.30
Total field time(h)	108.50	108.50	134.51	84.67	436.18
Machinery cost($)	2 566.41	2 566.41	3 004.49	2 065.08	10 202.4
Tractor cost($)	1 312.30	1 312.30	1 626.91	1 024.09	5 275.60
Total M&T cost($)	3 878.88	3 878.88	4 631.44	3 089.17	15 478.0
Cost per hectare($/ha)	63.90	63.90	76.30	50.89	63.75 (avg)
Cost per hour($/h)	37.75	37.75	34.43	36.48	35.49 (avg)

the tractor cost used for all crops. The comparisons show that it requires an additional tractor cost of only $437.29, $421.80 and $448.56 to increase from a one-crop operation of corn, field beans and wheat, respectively, to multiple crop operations for these crops. This example demonstrates the utilization of the tractor with the multiple crops compared with single cropping.

(c) *Machinery and tractor cost* — **Table 5** shows the summary for the machinery and tractor costs for the single cropping of corn, field beans and wheat on a 60.7-ha farm. The total machinery and tractor costs for single cropping of corn, field beans and wheat were calculated to be $9 550.88, $9 894.08, and $7 305.38, respectively.

Table 6 shows the summary for the machinery and tractor costs for each crop in a C-C-FB-W crop rotation. The machinery costs for each crop include the actual operating costs and the shared costs of using the implements. The actual costs were the operating cost of using each implement. They consist of labor cost, fuel cost, and oil cost. The shared costs consist of the repair and maintenance, and the fixed costs of capital consumption, and taxes, insurance, and shelter. The shared costs for each implement were calculated based on the proportion of time used for each crop to the total time used for all crops in a rotation. The total machinery and tractor cost for the corn, field beans, and wheat were calculated to be $3 878.88, $ 4 631.44, and $3 089.17, respectively. The total machinery and tractor cost for all crops was $ 15 478.03.

Tables 5 and **6** were used to compare the tractor and machinery costs between a single cropping farm and the same crop in a crop rotation. The comparison shows a savings of $5 672.00, $5 262.64 and $4 216.21 for corn, field beans, and wheat, respectively, when these crops were produced in a multiple crop farm. This example demonstrates that more crops in a rotation will increase machinery and tractor utilization.

Conclusion

The CPMS model was able to predict the size of tractors and implements required to complete the farm operation during a specified duration of time and to determine the compatibility of tractors and implements by properly matching the tractor power. The machinery cost analysis model was able to evaluate machinery costs to determine the most profitable combination of crops in rotations and to evaluate different farming alternatives either to scale up or down his farm operation. From cost analysis of the sample farms above, we can conclude that multiple crops in a rotation will increase machinery and tractor utilization, thus reduce costs and increase profits.

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Farm Mechanization and Potential of Agricultural Machinery Industry in Swaziland

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Abstract

The adoption of mechanical power in farming has been seen as the substitution of animal power and human labour in major parts of the industrialized world. The same may not be true, however, in developing countries and the strategy of farm mechanization has to be looked in a different perspective. The emphasis should be on increased productivity in an integrated farming system with all the resources optimally utilized with minimum labour replacement. There are about 2 million livestock head in Swaziland of which 800 000 (just about the same as human population) are cattle. The animal power, if properly harnessed, can make considerable impact in meeting the farm power need. In this report, different parameters like, need of irrigation facilities, available tractor and future power requirements, technological changes, and implications of agro-based industries, including unemployment problems are discussed. Finally, a suggestive overview is provided which may help in adapting a progressive mechanization policy with the aim of increased productivity and rural employment.

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Introduction

Agriculture in Swaziland is the most important sector of the economy from the standpoint of export earning, rural employment and sufficiency in family food. According to the Ministry of Agriculture of the Government of Swaziland, agriculture generates about 26% of the country's gross domestic product, contributes 75% to the export earnings, and absorbs approximately 75% of the total indigenous workforce, (Central Stat. Office, 1986). Therefore, its scope and expansion in the 21st century will be of great importance. Swaziland's area of about 17 360 km^2 is divided in four ecological regions (highveld, middleveld, lowveld and Lubombo Plateau) has variable climate and soil conditions and its full potential is yet to be realized. About 970 000 ha of land is under Swazi Nation Land (SNL) and 755 000 ha under Title Deed Land (TDL), with 11 000 ha covering urban areas in Swaziland, (Annual Statistical Bulletin, 1992). While maize and cotton are the major crops grown in SNL in addition to the livestock industry, the crops such as sugarcane, pineapple and citrus are successfully and profitably grown under TDL. SNL is mainly rainfed but TDL is well irrigated and the application of modern farming techniques is common.

As the population grows at the rate of 3.2% per annum, the demand for consumer goods will increase putting greater pressure on agriculture for more agricultural land to be brought under cultivation. This will then require careful planning in view of the increased demand for agricultural input, including skilled manpower under the scattered nature of Swazi homesteads. A typical farm size holding based on growing crops is only 1.93 ha (Annual Survey on SNL, 1990). In Swaziland, there are about 6 000 tractors of which half or so are not operational due to lack of parts and much needed expert services (April 15, 1993. The Times of Swaziland). On the other hand, there are over 120 000 head of draught animals which have a great potential as source of power in Swaziland farming. How land use should be pursued incorporating cropping pattern for a given machinery input and irrigation facilities integrated with livestock farming, is a complex problem. However, with the adoption of right policies, it is imperative that rapid agricultural development can take place in a given period of time.

In this report, different aspects like need for irrigation facilities, available tractors and future power requirements in agriculture, implications of agro-based industries and unemployment problems, which alter the extent of farm mechanization, are highlighted.

Process of Mechanization and Sufficient Food Production

The rural agricultural development sector has not received due attention in comparison to urban and industrial development sectors in Swaziland. The benefit of the industrial development sector has almost no effect on majority of the rural subsistence people due to low productivity at their end. There are many factors responsible for this situation. Lack of optimum mechanization is one of them. A fall in the labour force in a given agricultural production system warrants an increase in farm machineries, say, the number of tractors. In the present situation, when unemployment is high in the country, shortage of labour force would not pose any problem. One man and one tractor can replace three men and three teams of horses (Cracknell, 1994). The number of tractors in use in Swaziland has been consistently increasing from 1 812 in 1972 to 5 246 in 1991 and 4 274 in 1992 (Central Statistical Office 1972-92) but the production of food items could not result into the reduction of food import bills. The import bill of food and live animals is increasing at an alarming rate as shown in **Fig. 1**. Although natural forces like drought, crop diseases and hail storm have contributed towards stagnation of food production, the present agricultural policies seem to support medium and large scale farming to avail of the benefits of export earning for the country.

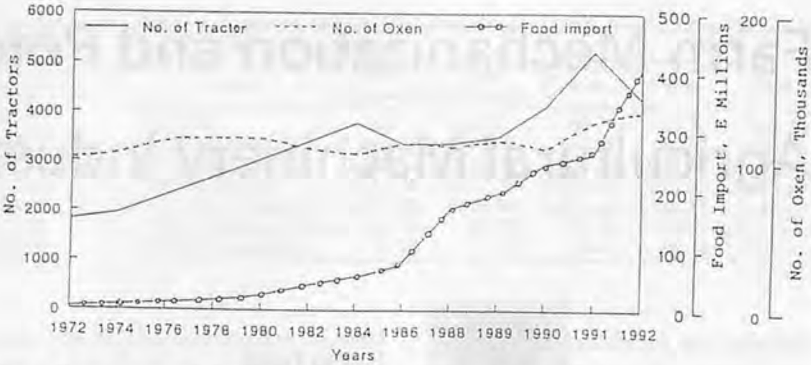

Fig. 1 Trends in tractor numbers: head of oxen and food importation.

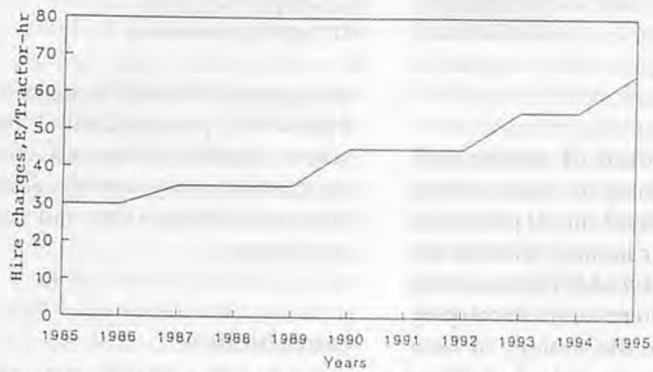

Fig. 2 Tractor hire charges for ploughing (3 bottom MB plough).

As farm mechanization progresses, power units like tractors declines in number indicating that the mechanization process may have plateaued. However, this is not the case in Swaziland. The number of tractors in use went as high as 5 246 in 1991 but went down to 4 274 in 1992. This indicates that there is sudden decline of 972 tractors in use just a year which is perhaps mainly due to non-availability of spare parts and the expertise to fix them. On the other hand, the number of oxen is fairly constant, except during 1992, '93 and '94, which suggests that more animal power is to be harnessed and use of appropriate equipment encouraged at subsistence level (**Fig. 1**). Besides, the typical farm size, based on growing crops is only 1.93 ha in Swaziland (Annual Survey on SNL, 1990) which limits the individual farmer's income. At present, there is an abundance of draught animals, including donkey, mules and oxen which have a great potential as source of farm power making mechanization process even easier. According to Peyton Johson (1973) in Cockrill's word, "too many people in many countries, even professionals, often forget that 3/4th of the world's farmlands are still tilled by humans helped only by domestic animals."

In view of the above discussion, an appropriate mechanization policy suitable to Swaziland's conditions needs to be pursued. It may involve research and development, including improvements on existing equipment and if such equipment are thoroughly tested and popularized, it would not completely wipe out the traditional methods of farming. This way the plentiful draught animals could augment part of the energy needs in farming.

Energy Need in Swaziland Agriculture

Energy utilization at the farmers' level involves heating (cooking and possibly drying of crops), running stationery power units (used for shelling, size reduction, and processing), water pumping, and operating mobile machines like in field operations and transporting farm produce and goods. The present discussion includes farm operations exclusively related to the crop production system. Accordingly, an estimate of energy requirement is provided. Of the total land area of Swaziland's 1.736 million ha only 195 000 ha is under crop-land, (Annual Statistical Bulletin 1992). The major crops grown are maize, groundnut, cotton, jugo beans, sorghum, sugarcane, beans, sweet potato, tobacco, cowpeas, cabbage, tomato, onion, carrot, sunflower, pumpkin, melons and some rice. Only a part of the total rural population, reported to be 473 374, is engaged in farming. According to Kline et al., (1969), a human being is rated at about 1/10th of a horsepower and as such an input of 47 337 persons shall be 4 733 hp or 3 640 kW (assuming 1/10th of rural population is engaged in farming at anytime). The total number of tractors in use is shown in **Table 1** which indicates that in 1991/92, 4 274 tractors were in use. If only 3 000 tractors are in use at any one time and each tractor is at least of 20 kW capacity, total farm power available then becomes to 60 000 kW.

Table 1 Number of Tractors in Use in Swaziland

Region	S.N.L.		I.T.F.		Total	
	1990/91	1991/92	1990/91	1991/92	1990/91	1991/92
Highveld	973	798	134	179	1 107	977
Middleveld	1 756	1 059	363	243	2 119	1 302
Lowveld	1 374	1 216	616	589	1 990	1 805
Lubombo	30	186	—	4	30	190
Total	4 133	3 259	1 113	1 015	5 246	4 274

Source: Annual Statical Bulletin, 1992. Central Statical Office, Mbabane, Swaziland.

The number of draught animals engaged in farm work have been fluctuating from 116 438 in 1980 to 132 711 in 1992, but the number fell to 113 695 in 1994, (Nxumalo, Directorate of Veterinary Services, Ministry of Agriculture, Mbabane, Swaziland). If the services of 12 000 head of oxen are available, it will add to another 60 000 hp or 46 154 kW (one pair of oxen equivalent to 1 hp). Thus the total energy available will be 109 794 kW from human, animal and tractor power sources. Now assuming the minimum power requirement for an effective agriculture is 1 kW/ha, a total of 195 000 kW is indeed required, leaving a deficiency of 85 206 kW which is about 44% of the total requirement.

In order to augment the deficiency in energy in agriculture, high-powered four wheel tractors are neither advisable nor economical for a subsistence farmer. Besides, it is the subsistence farm where manual power is used for almost all farm operations. Therefore, some power unit like two-wheel tractors, may be an alternative to energy input which are cheaper, economical and easy to use on small farms for a variety of services. The power tiller is 5 times more efficient in ploughing, 20 times in rotary tilling and 15 times in ridge making compared to manual operations doing the same job, (Nath, 1990). The required number of power tillers is dependent on the rate of implementation of motorized farming in Swaziland. If 50% of 85 206 kW is made available through the power tillers and the other 50% by four-wheel tractors, then further 6 086 power tillers and 2 130 four-wheel tractors may find place in Swaziland agriculture. This argument is based on the assumption that each power tiller and four-wheel tractor is equipment to 7 and 20 kW, respectively. It may take about 12 years to induct all the required power tillers and tractors if 507 units of power tillers and 178 units of tractors are introduced every year. It is emphasized that the old tractors presently in service should be replaced in time and the number of draught/farm animals be maintained at about 120 000 head.

Human, Animal and Motorized Power Farming

In a developing country like Swaziland, lack of capital and technical expertise, together with small sized farms pose a significant problem to decide a proper policy related to farm-mechanization. In the author's view, a farmer owning 1/2 ha or less is better off having only hand tools for field work, taking advantage of custom hiring for ploughing and other heavy work on the farm. Similarly, if a farmer has a farm more than 1/2 ha but less than 2 ha, he may be in a comfortable situation owning ox-drawn equipment provided there is enough pasture and means to feed the oxen during the dry period. Such a farmer may take advantage of custom hiring as well. But a farmer having 2 to 5 ha irrigated farm may go for partial mechanization like owning a power tiller with matching equipment and the one who owns more than 5 ha but less than 20 ha may very well think of owning a four wheel 20 to 30 kW tractors, (Author's personal experience).

A farmer convinced to opt for mechanized farming has to decide which machine to own for a given size of farm to undertake all farm activities. As most machines perform only one job over a small part of the year, machines with high annual use are most preferred. On the other hand, a farmer would like to own machines requiring very low initial investment yet providing timeliness of field operations. Sometimes the use of large machines can be spread over more and more units of service thereby reducing the difference in fixed unit costs between large and small machines. Hence, it is a complex problem to make a decision. However, the use of budgets which compares farm returns using different sources of power is an appropriate procedure and requires information about:

i) Substitution replacement rates among the human, animal and motorized power;
ii) Physical inputs and their cost-rate using different sources of power for a given size of farm; and
iii) Estimated production and its value using different sources of power for a given size of farm.

Credit facilities if available to the farmers can influence the mechanization policy in Swaziland. A comparative field performance of human labour, animal-drawn plough (different situations), two-wheel and four-wheel tractor are illustrated in **Figs. 3** and **4** (Nath, 1993). This is based on the work done in the Department of Land Use and Mechanization, and funded by the Research and Publication Unit of the University of Swaziland, where the performance of a newly designed ox-drawn plough was tested against different methods of use of the conventional plough. The field capacity of the new, conventional plough with 4 oxen and 2 laborers was 0.21 ha/day and 0.294 ha/day. The field capacity of the two-wheel and the four-wheel tractors were 0.128 and 2 ha/day. The cost of ploughing with the new conventional plough, two-wheel tractor and four-wheel tractors were E351.43, E501.43, E450.00 and E98.08/ha, respectively. The manual digging costs E759.20 and was costliest, (E4.50 = $1.0). Such information may be helpful in deciding the mechanization aspect keeping custom hiring services in mind.

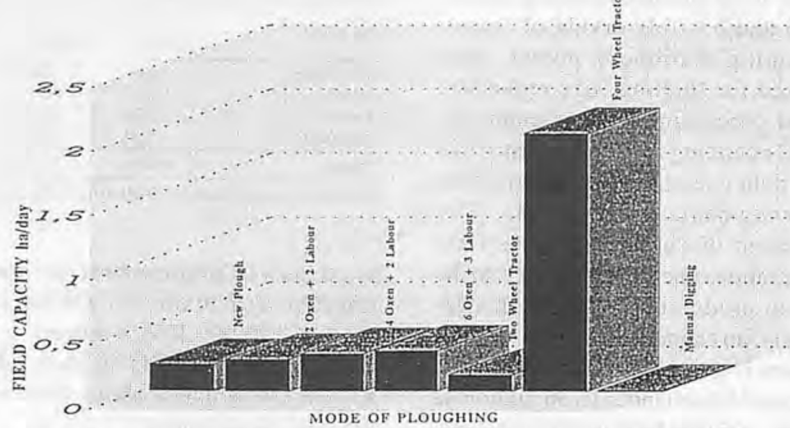

Fig. 3 Field capacity in different mode of ploughing.

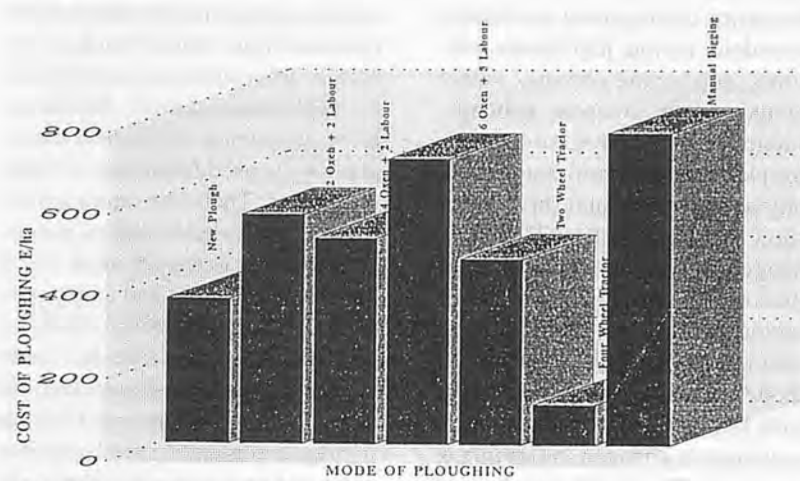

Fig. 4 Comparative cost of ploughing.

Alternatives to Ownership and Decision to Buy New or Used Farm Machinery

In general, a costlier and larger size farm machinery considerably reduces the weather risk by covering a large area within a short period of time, but the price-risk still remains a problem. Services of such a large machinery can be hired from those who own them and are ready to provide custom services. This may not be the perfect method from the standpoint of timeliness and the quality of work but first-come, first-served basis may prove quite satisfactory. Given the size of the country and approachable farm roads, the transportation of such machinery will be easier. Sometimes, it is advisable to own a machine in partnership or just exchange the services amongst the owner farmers. Another important factor to be considered is, whether to buy a new or used machinery. New machineries tie up larger capital than the used ones. Say, a farmer wants to decide whether to buy a new tractor for E80 000.00 or a used tractor for E48 000.00. The annual depreciation of the new tractor is E8 000.00 per year and has an economical life of 10 years. The used tractor has only 5 years of economical life and the annual depreciation comes to E9 600.00 assuming zero salvage value at the end of the economic life and no appreciable difference exists in both options. One may either buy the new

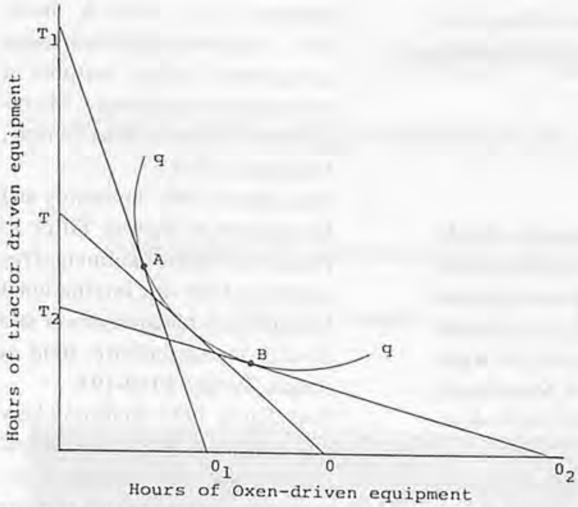

Fig. 5 Combination of tractor and oxen unit in a cultivation system.

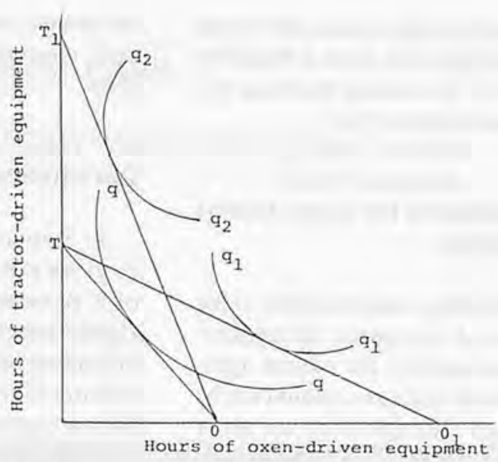

Fig. 6 Change in combination of tractor and oxen units as a result of technological change.

tractor with 10 years service or buy a used tractor worth E48 000.00 plus, raise another E48 000.00 to replace the used tractor at the end of 5 years ensuring an equivalent 10 years of service life. If the farmer can invest his funds in some other venture earning say, 20% per annum, the amount invested today will grow to E48 000.00 within 5 years will be 48 000 or E19 292.60 using the discount system. Hence, the farmer will buy a used tractor for E48 000 and invest E19 292.60 to provide a second used tractor at the end of 5 years, totalling the present investment to E67 292.60. This amount is less than E80 000.00 by E12 707.40. Therefore, the option of buying the used tractor is the least costly, and accordingly options of different agricultural machineries should be analyzed first before taking a decision.

Rate of Technical Substitution (RTS), and Technological Changes

If one considers the cultivation aspect, the output 'q' measured in ha/day can be achieved by either tractor-drawn equipment or by animal-drawn equipment. The 'q' is a parameter and is a function of O and T which can be attributed as input variables in the language or economist as shown in **Fig. 5**. 'O' is the number of hours of ox-drawn equipment operation and T is the number of hours of tractor-drawn equipment operation. The curve qq i called isoquant and for a given field coverage, q can be expressed as q = f(O.T.). Through total differentiation and finding the ratio of f1 and f2 which are partials dq/do and dq/dt, respectively, one can find f1/f2 = dT/do = RTS. The lines T_1O_1 and T_2O_2 in **Fig. 5** are called isocosts and where the slope of qq is negative, tractor use can substitute oxen use and vice versa. The optimum or least cost combination of T and O can be attained somewhere in that zone. T_1O_1 is the isocost when the unit cost of the tractor input decreases more than that of oxen input.

The optimum combination then is at point 'A'. T_2O_2 is the isocost when the unit cost of oxen input decreases more than that of the tractor input and the optimum combination is at 'B'. Assuming the unit cost of O and T are CO and CT and total budged available for O and T is Bt, the slope of isocost line will be, CO/CT which is equal to intercept on 'Y' axis/intercept on 'X' axis.

Figure 6 shows the situation where the unit price of the input drops while the price of other inputs remains constant. In that case, the same amount of available budget for the inputs can be used to cultivate a larger area q_1 and q_2. Such an approach helps in decision making and adjusting to the technological changes occuring in the farming techniques.

Swaziland cannot afford sudden changes in farming resulting from rapid technological changes. A shift to 100 percent motorized farming may result in non-utilization of the full potential of draught animals. However, if improved and efficient equipment/techniques are incorporated as a change, it may have a positive effect. For example, if a plough is developed such that it can be operated by one labourer and a pair of trained oxen, it can help in reducting the unit cost of operation in comparison to the unit of 4 or 6 oxen with 2 or 3 laborers. The trend of tractor hire charge is shown in **Fig. 2** and if the farm labour charges are comparatively not high, the use of manual labour can be an alterative for small holding farmer. This way, more animal operated units can be employed for cultivation. It is mentioned here, however, that a higher level of mechanization or biased technical change lowers the labour input which may have a negative effect for Swaziland from an exployment point of view.

Implications for Agro-based Industries

It is highly imperative that in the process of increasing the agricultural production, the related agro-based rural industries should not be forgotten. Though there are many problems facing the rural *swazi* (both farmers and potential enterpreneurs), a long term strategy should be developed to start agriculture-based rural industries. The factors responsible almost for the non-existence of such industries in rural areas are lack of finance, energy, trained man-power, interest towards research and development and appropriate technology itself. The Gwamile Vocational Training Institute in Matsapha, (VOCTIM) has trained 700 personnel so far in different trades and so has the Manzini Industrial Training Centre (MITC), but benefits of these trades have not seeped through to rural industries. Looking from the farm mechanization perspective, it appears that almost all the agricultural machineries are imported abroad, including hand-tools and animal-drawn equipment. The establishment of a research, development and testing centre purely for agricultural machineries will help towards meeting the objective of self-sufficiency in food supplies. Machineries could be tested for their performance and can be modified to meet the requirements of the kingdom of Swaziland. Such strategy shall prompt the fabrication of the machineries in Swaziland itself providing after sales services to customers. The use of local materials and expertise must be emphasized as far as possible in order to create employment. Technology is a driving force for the development of a nation that requires perserverance on the part of the planners, executioners and customers alike.

Conclusions

1. Serious consideration should be given towards the establishment of a Research and Development Centre attached to an educational institution like the Faculty of Agriculture, University of Swaziland. Such a centre can fulfil the following objectives:

i) Develops, fabricates and tests the agricultural equipment for suitability to Swaziland's needs and conditions;

ii) Evaluates various field operations of the equipment intended to be imported in to Swaziland;

iii) Impart training for repair and maintenance of tractor and related equipment machineries used by farmers; and

iv) Impart training to educated unemployed individual to establish and run agro-service centres.

2. Rural agro-industries should be set up in rural areas in order to provide employment.

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Evaluation of Three Bush Clearing Methods in Primary Forests of the Humid Tropics

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Abstract

Three bush clearing methods have been evaluated on the basis of their influences on growth and yield of maize and cowpea, soil organic matter depletion, bulk density and costs in terms of time and money. The location of the experiment was at the Oluwa Forest Reserve of the Ondo State World Bank-assisted Afforestation Project.

The Bush clearing methods are:

1. Clear-felling using powered chain saw, (CSB);
2. Clearing with the use of bulldozer for bulldozing and windrowing, (BW); and
3. Clearing with the use of bulldozer just to knock down trees which are later cross-cut with power chain saw, packed and burnt in-situ, (BNW).

Crops performed best under the CSB method where the average maize yield was 4.08 t/ha compared to 2.58 t/ha for the BW method. The loss in soil organic matter and other nutrients was highest with the BW method. As much as 43% of organic matter was lost at the end of one year of cropping. Organic matter loss was least with the BNW method which recorded 25.7% loss, a little lower than 27.0% for the CSB.

Clearing with the use of the bulldozer for bulldozing and windrowing, BW came out to be the fastest and cheapest method of bush clearing. While clearing takes 12.5 h/ha and costs N12 500/ha (US $600.00) for the BW method, as much as 450 h/ha and N57 666/ha (US $2 600.00) were obtained for both time and cost, respectively, under the CSB.

On the basis of these findings, the CSB and BNW methods are recommended for use in the primary forests of the humid tropics, but for large hectarages, the BW which should be cautiously done is preferred.

Acknowledgements: The authors wish to record their appreciation to the GTZ through the International Board for Soil Research and Management, IBSRAM, for sponsoring this work. They will also like to thank the Project Manager of the Ondo State Afforestation Project at Lisagbede, Mr. A.B. Ogunlade for his numerous assistance to see this work through.

Introduction

Increasing local food production is a top priority in present-day Nigeria. In the last two decades each successive government had always tried its best towards this goal of feeding the ever increasing populace. There were the River Basin Development Authorities (RBDAs) followed by the Operation Feed the Nation (OFN). There was also teh Green Revolution (GR). Apart from these, there were other governmental organizations such as the Agricultural Development Projects (ADPs), the Directorate of Food, Roads and Rural Infrastructures (DFRRI) and recently, the National Agricultural Land Development Authority (NALDA) formed to boost both food and cash crop production.

The implications of these efforts are that more lands are being opened up for farming activities and more research works are being undertaken to produce improved varieties of high yielding quality crops that are drought, pest and disease resistant and thus low management levels. Agboola (1985) reported that large scale land clearing activities started in the Old Western Region of the 1960s for the Farm Settlement Scheme, though it is unfortunate that today the farm settlements are no more.

The Government also did massive importation of fertilizers to replenish the dwindling fertility status of the farm lands (Adegboye, 1986). The bulk of the food items in the market still comes from the peasant farmers owning 2-3 ha of cultivable farmlands. The few large scale farms in the country belong to either companies whose main interests are just production of their raw materials or some private individuals (generally retired public officers) who manage to get sizeable amount of credit with which to invest in farm practices. There are records to show that many of these large scale food crop producing farms have now packed up due to several reasons among which is total loss in soil fertility. Even the "overdose" application of fertilizers could not resuscitate these lands.

The primary cause of the speedy collapse of these farms has been attributed to the bush clearing methods adopted. Experience has shown that most of the operators handling the bulldozers do not have any formal training in land clearing for farming purposes, and that is why each time a bulldozer is used on the field, the resulting land is as if it is meant for building purposes rather than farming business.

Since more lands will be opened up for farming activities and there is no legislation over what method of bush clearing to adopt. It is, therefore, necessary to do all that is possible to save our soils from the abuse of machines, ignorance and chemical fertilizers. Tropical soils have the attributes of being fragile, low in fertility status and shallow depths. Therefore the use of heavy machineries like the bulldozer in bush clearing should be closely monitored and curtailed. When the bulldozer is not used properly, the soil is totally disturbed. There is heavy compaction leading to intolerably high bulk densities and low infiltration rates. The top soil which harbours the soil nutrients for plants' use is removed and there is massive erosion which in turn leads to soil loss through runoff (Seubert et al. (1977)).

In this paper, three bush clearing methods used on a primary forest land are examined on the basis of yield of crops grown immediately after land clearing, effectiveness of method and effective area of cropping, and effects of methods on the physical and chemical properties of the soil and cost of clearing operation. This is done with the view of advising on which method to adopt for the kind of forest in the region.

Materials and Methods

The experimental site used is the 2-ha land characterized by Agboola and Ogunkunle (1993). This is a primary forest located at Epemakinde in the Ondo State Afforestation Project area about 200 km and 2 hours drive away from Ibadan (4°45'E and 6°45'N). The soil are slightly to fairly acidic (pH 4.9-6.7); medium textured (Sandy Loam to Sandy Clayey Loam top and Sandy Clayey Loam to Sandy Clayey Clayey below) and moderately well structured (granular/crumb top and sub-angular blocky below). The initial operation was line tracing to demarcate the characterized land into 3 blocks of 9 plots each. Each plot is 20 x 30 m with 3 m inter-plot spacing and 4 m inter-block spacing.

The labour used for the slashing is sourced from the able-bodied young men of the practical year students of the faculty of Agriculture and Forestry, University of Ibadan.

Three land clearing methods were investigated. These are: (1) Bulldozed and windrowed, (BW); (2) Bulldozed not windrowed (BNW); and (3) Cutting with powered saw, burning (CSB)

Bulldozed and Windrowed

This involves the use of the Komatsu Bulldozer Model D 55 with front mounted dozer blade to knock down the trees and later windrowing them. Minimal packing and burning was done on such plots to make them ready for maize planting. Such plots could as well pass on for tillage operations (**Fig. 1**).

Bulldozed Not Windrowed

The same Komatsu Bulldozer model D55 is used in this case just to knock down the trees without windrowing. The trees are then cross cut, packed and burnt *in-situ*. A second stage slashing, packing and burning makes the plots ready for maize planting (**Fig. 2**).

Fig. 1 A plot bulldozed and windrowed.

Fig. 2 A plot (BNW) bulldozed not windrowed. Knocked down trees cross-cut, packed and burnt.

Fig. 3 A CSB cleared plot with logs being cross-cut.

Fig. 4 A plot under CSB clearing showing stumps. Plot is ready for maize planting.

Cutting with Powered Saw, Burning

This method involves the use of machetes and cutlasses to cut down the undergrowing shrubs and powered chain saw for felling the trees. The initial operation here is to underbrush (slash) the shrubs to have a clear view of the forest. Then the trees are cut 50-100 cm above the ground one week after underbrushing. This was in December 1993 - January 1994. The slashed plots were then set on fire. This initial burning was to allow easy passage and maneuverability of the chain saw operator. Next is re-slashing, cross-cutting, packing and burning. In this cross-cutting operation the trees are cut into logs of 1-5 m long depending on the size (girth) for easy lifting (**Fig. 3**). A third stage slashing, packing and burning was done to make the plots ready for maize planting. Because of the enormous stumps left over, tillage was not done but rather deferred till the following year, 1995 (**Fig. 4**).

Crop Planting

The plots were planted to maize at a rate of 55 000 seeds/ha, i.e., at a spacing of 60 x 90 cm. This was in June/July. Necessary cultural operations like spraying with herbicide (gramozone) and manual weeding were done. The maize was harvested in September and immediately after harvesting the plots were sprayed with gramozone before they were planted to cowpea at a similar spacing of 60 x 60 cm, but seeding rate of 37 000 seeds/ha.

Measurements Taken

Three categories of measurements were taken. These were those on (i) bush clearing; (ii) growth and yield of the crops planted; and (iii) soil properties..

Bush Clearling Measurements

These are:

i. Duration of each clearing process per plot;
ii. Number of labour used for such process;
iii. Costs involved in terms of labour charge/wage; and
iv. Height above the ground and girth of the stumps and trees left behind in the plots cleared by cutting with powered chain saw and burning.

The crop growth parameters taken include plant high, number of functional leaves, stem girth, leaf area, number of ears per plant, plant population, height of ear bearing node while the yield parameters measured include fresh cob plus husk, fresh stover weight, dry stover weight, number of cobs and weight of shelled cobs.

For the growth data sampling, each plot consists of 22-23 rows out of which 5 rows were sampled from the 3rd, 6th, 9th, 12th and 15th rows. Along the row, the sampled plants are the 6th, 12th, 18th, 24th, 30th and 36th plants.

The three bush clearing methods were evaluated on a number of factors which include the following: growth and yield of maize and cowpea, clearing costs in terms of money and time, soil organic matter depletion and soil bulk density. The area occupied by stumps, standing trees and root outcrops in the manually cleared plots was also examined to see if it has any influence on the parameters measured.

Organic carbon was determined by the method outlined by Walkey and Black in Nelson and Sommers (1982). From this organic matter was estimated, as percentage, organic carbon multiplied by a factor 1.72. This was done for two depths 0-15 and 15-30 cm, both at the beginning of the experiment before bush clearing and at the end of one year of post-clearing cropping of maize and cowpea.

Results and Discussion

Effect of Clearing Method on Growth and Yield of Maize and Cowpea

Maize — In all the four parameters examined, that is, yield (t/ha); number of cobs per ha; plant height 8 weeks after planting (8 WAP) and ear height at harvest (cm), maize performed best under the plots cleared by cutting with powered saw, then burning, otherwise called clearfell, slash and burn (CSB). **Table 1** shows the results obtained. While an average yield of 4.08 t/ha was obtained in the clearfell, slash and burn (CSB), the bulldozed and windrowed plots (BW) recorded just 2.58 t/ha. The plots bulldozed but not windrowed (BNW), however, yielded better results than the BW plots.

Statistical analysis (ANOVA) showed that the bush clearing methods had effects on the yield as the differences obtained were found to be highly significant at 5% level of significance. A similar result was obtained for the blocking. Block 3 happened to yield the best results in these parameters. The reason for this block effect could be as a result of the location of Block 3 which places it at an advantage over the other two. The block which is bounded by road network also has clear vegetation bounding it, whereas block 1 is bounded by uncleared forest. Though differences in the values obtained for the other parameters (number of cobs per hectare, plant height 8 WAP and ear height at harvest) were not significant, the CSB method recorded the highest values. The order of performance is CSB better than BNW which is in turn better than BW.

Cowpea — Similar trends in performance and behaviour were obtained for the parameters examined for cowpea even though the differences were not statistically significant. The highest average values were obtained under the CSB method for the yield, number of pods and stover yield per hectare. The BW method recorded the least values in these parameters (**Table 2**).

Effect of Clearing Method on Soil Organic Matter Depletion and Bulk Density

Soil organic matter — The re-

Table 1. Maize Growth and Yield Parameters under Different Bush Clearing Methods

Parameters	Bush Clearing Methods*			CV%	LSD (5%)
	CSB	BW	BNW		
Yield (t/ha)	4.08	2.58	3.65	6	47.78
No. of cobs/ha	55833	52800	53333	90	ns
Plant height (cm)					
8 WAP	237.23	205.84	22492	7	ns
Ear height (cm)	100.74	84.52	93.68	11	ns
Stump area (m^2)	18.33	—	—	—	—

*Values are means of 3 plots/block.
BW - Bulldozed and windrowed.
BNW - Bulldozed not windrowed.
CSB - Clear-felling using powered chain saw, then burning.
Stump Area - Area occupied by stumps, root-crops and standing trees.

Table 2. Cowpea Growth and Yield Parameters under Different Bush Clearing Methods

Parameters	Bush Clearing Methods*			CV%	LSD (5%)
	CSB	BW	BNW		
Yield (t/ha)	1.31	0.95	0.97	17	ns
No. of pods/plant	12.92	10.76	11.00	36	ns
Plant height (cm)	101.35	78.02	84.62	19	ns
Stover yield (t/ha)	1.47	1.09	1.23		ns
Stump area (m^2)	18.33	—	—		—

*Values are means of 3 plots/block.
BW - Bulldozed and windrowed.
BNW - Bulldozed not windrowed.
CSB - Clear-felling using powered chain saw, then burning.
Stump Area - Area occupied by stumps, root-crops and standing trees.

Table 3. Effect of Bush Clearing Methods on Percent Soil Organic Matter

Treatment	Initial Values		1st Year		% Loss	
	0-15	15-30	0-15	15-30	0-15	15-30
BW	5.3	3.0	3.01	2.17	43.2	27.7
BNW	5.3	3.0	3.94	2.58	25.7	14.0
CSB	6.3	3.0	3.87	2.29	27.0	23.7
BNP	5.3	3.0	3.94	2.24	25.7	25.3
CSBNP	5.3	3.0	4.47	2.86	15.7	4.7

BW = Bulldozed and Windrowed.
BNW = Bulldozed Not Windrowed.
CSB = Clear-fell, Slash and Burn.
BNP = Bulldozed Not Planted.
CSBNP = Clearfell, Slash and Burn Not Planted.

Table 4. Soil Bulk Density under Different Bush Clearing Methods (g/cm^3)

Treatment	Average Values	
	0-15 cm	15-30 cm
BW	1.45	1.63
BNW	1.46	1.74
CSB	1.40	1.56
NF	1.10	1.41
CV%	13	14
LSD	ns	ns

NF = Natural Forest.
BW = Bulldozed and Windrowed.
BNW = Bulldozed not Windrowed.
CSB = Clear felling using powered chain saw, slash and burn.

Table 5. Time and Financial Costs per ha of Bush Clearing Operations

Treatment	Time (h)	Financial cost (N)***
BNW	192.20*	25222.22
BN	12.50	12500.00
CSB	316.67	24333.33
CSBS	450.00**	57666.66

CSBS-Clearfell, slash and burn plus stumping.
* Value obtained from time cost in Bulldozing Not Windrowing (30 min/plot) + time cost in cross-cutting 3 hrs/plot + time cost in packing and burning, 8 hrs for 4 persons per plot).
** Value obtained as time cost for underbrushing, clearfelling + Cross-cutting + time for packing and burning + time cost for stumping (8 hrs/plot by 4 persons).
*** Exchange rate US$1.00 = N22.

sults obtained showed that organic matter depletion was highest in the plots under BW at both depths, 43.2% and 27.7% losses, respectively, for 0-15 and 15-30 cm. The loss was least in the plot CSB but not planted (15.7 and 4.7% at depths 0-15 and 15-30 cm, respectively) (**Table 3**). The effect of bush clearing method on changes in soil chemical properties was also examined but not discussed in this paper. The result, however, showed an apparent decline of the status of nutrient elements in the soil with time and depth, and this is more pronounced in the BW plots than any of the other bush clearing methods.

Soil bulk density — The soil bulk density after one year post-clearing cropping was also examined. The result obtained is shown in **Table 4**. The values obtained ranged from 1.40 g/cm^3 of the CSB method to 1.46 g/cm^3 in the BNW method at the 0-15 cm depth. Although there are slight differences among values obtained for the bulldozed plots versus the natural forest, and the clearfell, slash and burn versus bulldozed plots, these differences are, however, not significant statistically. The natural forest, however, has average values of 1.10 and 1.41 g/cm^3 for the 0-15 cm and 15-30 cm depths, respectively.

Time Cost in Clearing Operations

The time taken for each of the clearing operations was determined. This was necessary because of the importance of timeliness in critical operations in agriculture-one of which bush clearing is. Results show that while 4 healthy and strong men working at the rate of 8 hours per day for the brushing, packing and burning, completed just one plot of 20 x 30 m^2, the operator working with powered chain saw completed the same plot size in 3 hours for clear-felling, and cross-cutting. Bulldozing with windrowing took 30 min/plot while bulldozing without windrowing took 45 min/plot. The time cost per ha was estimated and while BW took 12.5 h/ha, BNW, on the other hand, took 192 h/ha, the time for cross cutting, packing and burning inclusive (**Table 5**). The CSB method took 317 h/ha or 450 h/ha with stumping inclusive.

Bulldozing and windrowing as a single bush clearing operation was thus found to be the quickest and its adoption has to be considered on the basis of what would be gained in terms of time of accomplishment as against the losses that would emanate from the soil disturbance like rapid loss in soil fertility, high bulk density and others. The time cost in the CSB could, however, be reduced if the preliminary underbrushing was thoroughly done and burnt early enough before their regrowth. Their re-growth which is very rapid even in the dry season (November-February) slows down the subsequent operations of clear-felling, cross-cutting, packing and burning. The alternative to lowering the time cost in CSB is to increase the number of labour for brushing, packing and burning and also the operator for clear-felling and cross-cutting.

Financial Cost of Bush Clearing

At the time the experiment was being established, the following work rate charges were in operation:

Bulldozer hiring
- N1000/h

Labour hiring
- N120/day of 8 h

Clear felling + cross cutting
- N500/plot or N8333/ha

Stumping
- N2000/plot or N33 333/ha.

Based on the above, the charges for bush clearing operations ranged from N12 500/ha for bulldozing and windrowing (BW), to N57 666/ha for clearfelling, slashing, stumping and burning. Bulldozing without windrowing was, however, N25 222.22, about twice the cost for bulldozing and windrowing (**Table 5**). Clearing by CSB is thus the most expensive of the three methods considered. This is as a result of the numerous operations involved, all of which are manually done and, therefore, time and energy consuming.

Stumping was not done until the end of the cropping of cowpea when the land was being prepared for tillage. Clearing by CSB method was N24 333.00/ha about twice the cost for bulldozing and windrowing. This cost will definitely increase if more hands are employed but then, the time cost will correspondingly decrease.

Effect of Stump Area on Yield and Growth of Maize and Cowpea

Tables 1 and **2** show the result obtained for the maize and cowpea yield and growth parameters, respectively, as well as the corresponding areas occupied by stump, root-outcrops and standing trees in the CSB cleared plots. The area occupied by stumps and others range from 13.20 in block 3 to 27.15 m^2 in block 1, the average being 18.33 m^2.

A correlation analysis done for the maize and cowpea yield versus area occupied by stumps and root-outcrops show that while maize is slightly negatively related to the area occupied by stumps, cowpea yield, on the other hand, is very closely related to the stump area, also in negative way. The correlation coefficient obtained in both cases are -0.4 for maize and -0.9 for cowpea. That is, as the stump area increases, yield decreases for both crops. This means that the yield of the crops is affected by the presence of stumps and the implication is that, although the yield obtained was highest under the clearfell, slash and burn, CSB Could have been much more if the stumps and root-outcrops had been removed before planting.

General Discussion

While losses in the BW in terms of soil nutrient (soil organic matter) and other soil features are not redeemable, more gains are derivable under manual clearing, the extra cost in time and money notwithstanding. For example, coupled with the fact that better yield and crop performance are obtained for CSB clearing, the life span of the soil is longer, and the soil can be cropped for many years. On the other hand, the soil under BW becomes less productive with time and the need for heavy fertilization with artificial fertilizer sets in. Thus the gains made at the initial stage of bush clearing will now be used up for post-clearing management and at the end of the day the land will be abandoned for low productivity due to heavy loss in soil nutrient and huge overhead costs in soil management. Time can be saved under the CSB clearing method by increasing the labour, though this will further increase the cost.

Conclusions and Recommendations

From the results obtained, the following conclusions can be drawn:

1. The bush clearing method affects the growth and yield of maize and cowpea. The crops performed best under CSB clearing followed by bulldozing without windrowing, BNW.
2. Bush clearing method influences the loss of soil organic matter and other plant nutrients in the soil thus rendering the soil less productive. The losses are highest under the bulldozed and windrowed method and lowest with the bulldozed not windrowed method. It is in the process of windrowing that the top soil which habours the plant needs for good growth and performance is greatly disturbed.
3. Opening up the land increases the soil bulk density. Although the differences among values obtained for the bush clearing methods are not significant, the CSB cleared plots still recorded the lowest increase in soil bulk density.
4. Under manual clearing without stumping, the area occupied by stumps and root-outcrops influence the yield and growth of maize and cowpea. Increase in stump area decreases the yield of the crops planted.
5. Manual bush clearing is the most expensive and slowest method in terms of money and time. Manual clearing costs as much as five times the cost of mechanical clearing with bulldozer.

On the basis of the results obtained from the growth and yield of maize and cowpea, increase in soil bulk density and organic matter loss and costs of bush clearing (both time and money), two methods of bush clearing are recommended for use in primary forests of the humid tropics. These are:

(1) Clearing using a powered chain saw to fell and cross-cut the trees and cutlass, axe and machetes for slashing, packing and stumping; and
(2) Mechanical clearing (BNW) which includes the use of the bulldozer to knock down the trees without windrowing while the trees so felled are cross-cut, packed and burnt in-situ or extracted for use as firewood.

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3. Use File Transfer Protocol (FTP) from SWEETPEA. ENGR. UCDAVIS. EDU (or 128. 120. 65. 61 for those wishing to use the IP address). Give as a User name: anonymous, and as a Password: guest. Before "getting" ae-ndx97. exe, first type: binary (enter)
4. Mail a formatted (IBM Compatible) 1.44 Mbyte, 3 1/2-inch diskette to:
   W. J. Chancellor
   Biological and Agricultural Engineering Department
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   Davis, CA 95616-5294, USA

The file, AE-NDX97. EXE, will be transferred to the diskette, and the diskette will be returned to the sender. The file, AE-NDX97. EXE, should be placed on a hard disk drive in a subdirectory by itself. Then, typing AE-NDX97 (enter) will produce a system ready to use upon typing: HI (enter).

Those who have access to the Internet may search on-line an expanded agricultural engineering finder system index by TELNETing to SWEETPEA. ENGR. UCDAVIS. EDU (or 128. 120. 65. 61), and when the prompt: "Username:" appears, type: SEARCH (enter). No password is required, and there is no charge.

Effect of Two Mulch Types for Solarization on Soil Temperature

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Abstract

The effectiveness of transparent and black mulch for soil solarization was evaluated in a field experiment conducted in the Al Ain area of the United Arab Emirates (U.A.E.) during the month of July 1996. After proper land preparation, the moist soil was covered with either transparent or black mulch, or left uncovered, throughout the month. The soil temperature was measured at depths of 5, 10 and 20 cm. Both transparent and black mulch significantly increased the soil temperature as well as the duration of increased soil temperature. This resulted in proper control of the soil-borne fungi, nematodes and weeds. Transparent mulching was superior in increasing the soil temperature, controlling the soil-borne pests and increasing the tomato yield. It is recommended that soil solarization be widely applied in the U.A.E. during the hot summer periods for effective control of soil-borne pests and proper maintenance of the healthy environment.

Acknowledgment: The authors express sincere thanks to the U.A.E. University for providing the financial support and to the Department of Agriculture and Animal Resources in Al Ain for providing field and technical assistance.

Introduction

The increased vegetable cultivation in the United Arab Emirates in recent years has been associated with the development of several pest problems, including those induced by soil-borne fungi, nematodes and weeds. Therefore, different control measures such as heavy increased pesticide applications; soil fumigation, crop rotation and deep ploughing have been applied. However, results of these measure are not satisfactory. In addition, intensive application of pesticides, which influences the soil and environment contamination, necessitates other effective and safe pest control strategies.

In recent years, soil solarization with black or transparent plastic mulch (polyethylene sheets) has been described in several hot countries as a safe integrated pest management technique for the control of soil-borne pests and weeds (Abu-Gharibieh, 1989; Elmore, 1991; Abu-Irmeileh, 1991). Other scientists have demonstrated the superiority of the transparent mulch in increasing the soil temperature and controlling soil-borne pests (Bhella, 1986; Devay, 1991). Therefore, the present study was conducted to evaluate and compare the effectiveness of the transparent and the black mulch for the increase of the wet soil temperature during the hot summer month in the U.A.E. Also studied was the impact of increased soil temperature on the control of the soil-borne pests in the Al-Ain area.

Materials and Methods

The present study was conducted in the U.A.E. at Al Ain (Latitude N24° 44, Longitude E55° 46 and Altitude 306 m above sea level). It was carried out in a plot of the Al Qattara district known to be infested with soil-borne fungi, nematodes and weeds. The soil of the plot was sandy loan containing 84% sand, 9% silt, 7% clay and a pH of 8.3. The plot was deeply ploughed, harrowed, leveled and divided into 48 subplots, 20 x 2 m each. Irrigation lines were laid in the middle of the plots. Organic manure was incorporated in the soil (1.56 kg/m^2) and the soil was heavily irrigated early July 1996. The moistened plots were covered for one month with either transparent or black mulch (polyethylene sheets) or left uncovered as control plots.

The trial was conducted in a completely randomized block design with three replicates. The soil temperatures were recorded with thermocouples fixed at 5-cm, 10-cm and 20-cm depths under the transparent and the black mulch (each 100 m thick) and in the non-covered control plot. The soil temperature was constantly recorded throughout the month of July, 1996. The soil-borne fungi and nematode population were counted before and just after mulching. The tomato seedlings *Lycopersicom esculentum* Mill. (cv. 'Calypso') were transplanted in early October 1996. They were soon covered with non-woven fabrics (Agryl p.17) for one month to prevent the vector of tomato yellow leaf curl virus infestation. The weed infestation was determined (fresh and the dry weights) 10 weeks after the tomato planting. The final tomato yield (of each plot) was also determined. The data of the temperature, pest population and tomato yield were statistically analyzed and means were separated according to LSD at $p < 0.05$.

Table 1. Effect of Transparent and Black Mulch on Soil Temperature

Mulch Type	Soil Depth (cm)	Maximum Soil Temperature °C	% Increase Maximum Soil Temperature	% Increase Mean Soil Temperature
Transparent	5	60.3	40	30
	10	53.5	30	25
	20	51.0	31	26
Black	5	56.0	30	22
	10	48.8	18	16
	20	46.2	19	17
Uncovered soil	5	43.0	—	—
	10	41.2	—	—
	20	39.0	—	—

Table 2. Comparative Effects of Soil Solarization on Population of Soil Pests and Tomato Yield (Unit: Percent)

Mulch Type	Total Fungi Population	Total Nematode Population	Total Weed Infection	Root Knot Infection	Tomato Yield
Transparent	3.1	0.0	15	3.3	347
Black	1.8	0.0	19	7.5	303
Bare	100	100	100	100	100

Results

Soil solarization with transparent or black mulch significantly increased the soil temperature throughout the course of the experiment in July 1996. As shown in **Table 1**, maximum soil temperatures reached under the transparent cover were 60.3, 53.5 and 51°C at depths of 5, 10 and 20 cm, respectively. The maximum soil temperature reached under the black cover was 56.0, 48.8 and 46.2°C at depths of 5, 10 and 20 cm, respectively. The maximum temperature in the uncovered soil was 43.0, 41.2 and 39.0°C at 5- and 29-cm depths, respectively. The table also shows flat a percentage increase in soil temperature as a result of solarization. Transparent mulch increased the soil temperature by up to 40% while the black mulch increased the soil temperature at 5-cm depths, by up to 30%.

The effect of soil solarization on the soil temperature in **Fig. 1** shows that the transparent mulch increased the mean soil temperature by up to 47.7°C at 5 cm depth, while the back mulch increased the mean soil temperature by up to 44.8°C at 5 cm depth. Both covers also increased the mean soil temperature at 10 cm and 20 cm depths. Moreover, as shown on **Fig. 2**, the soil temperature of 45°C under the transparent cover was retained for 367, 327 and 300 hours during July 1993 at 5, 10 and 20 cm depths, respectively. The black cover retained the soil temperature above 45°C for 320, 155 and 79 hours at 5, 10 and 20 cm depths, respectively. Also, the transparent cover retained the soil

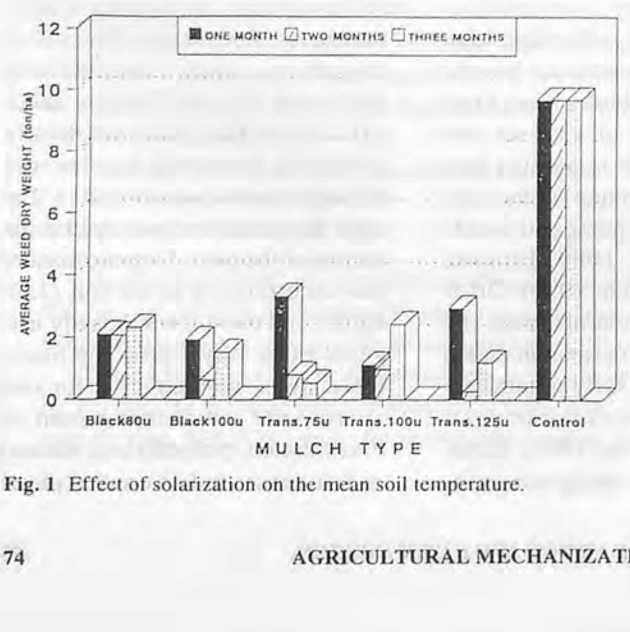

Fig. 1 Effect of solarization on the mean soil temperature.

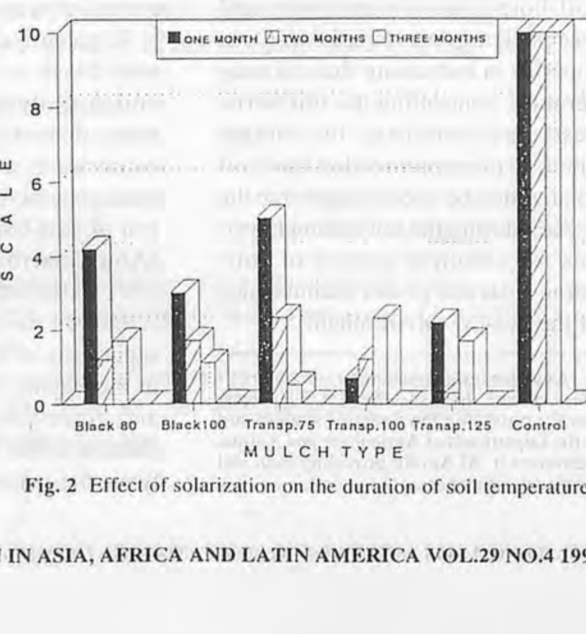

Fig. 2 Effect of solarization on the duration of soil temperature.

temperature above 50°C for 237, 103 and 60 hours at 5, 10 and 20 cm depths, respectively. The black cover retained the soil temperature above 50°C at 5 cm depths for 189 hours. The soil temperature of the non-covered soil was not retained above 45°C.

The effect of the increased soil temperature, due to mulching application, on the soil-borne pests and the yield of tomato is summarized in **Table 2** showing that mulch with transparent or black covers, when compared with the non-covered soil, resulted in 96.9 and 98.2% reduction in total weed infestation, 96.7 and 92.5% reduction in the root knot nematodes infection, and 347 and 303% increase in the tomato yield, respectively.

Discussion

The results of the present investigations showed that soil solarization at the Al-Ain area during July 1996, with transparent or black mulch increased both the soil temperature and duration of attained high temperature. Such temperature resulted in significant control of the soil-borne fungi, nematodes and weeds and increase in the tomato yield. In similar trials in Jordan, Abu-Gharbieh (1989) and Abu-Irmeileh (1991) demonstrated the effectiveness of soil solarization in increasing the soil temperature and controlling the soil-borne pests. Moreover, the present work has shown that the highest increase in soil temperature, in tomato yield and the highest reduction in soil-borne pests were obtained from plots covered with transparent mulch. In a similar work on solarization, Bhella (1986) and Devay (1991) it also demonstrated that transparent mulch was superior to black ones in increasing soil temperature for solarization. The significant increase in tomato yield reported in the present work was attributed to the control of the soil-borne fungi, nematodes and weeds. As stated by Lirke et al., (1991) the role of solarization on the release of nutrients and on the improved physiochemical conditions of the soil should not be ruled out.

Conclusion

It is concluded that the application of soil solarization in U.A.E. is highly recommended for controlling soil-borne pests and preserving the safety of the environment, as no pesticides are used in the solarization for the control of soil-borne pests. In addition, transparent mulch outperformed other types and retained more heat for longer period of time, consequently, it had a better effect for controlling soil-borne pests.

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NEWS

Agricultural Equipment Technology Conference '99

February 8-10, 1999
Louisville, Kentucky, USA

This fourth Agricultural Equipment Technology Conference (AETC '99) is again sponsored by the Power and Machinery Division of ASAE. AETC '99 will bring together engineers, managers, researchers and other professionals in the agricultural equipment industry to exchange information, discuss opportunities and address challenges for production agriculture in the 21st century.

AETC '99 will focus on machinery and machinery systems for agricultural production. Invited speakers will address issues such as precision farming, turf & landscape, manufacturing, new equipment, electronics, and international business growth. A technology transfer session will feature exhibits of leading-edge products and systems and the latest in academic and applied research.

Each year ASAE and *Resource* magazine, selects and honors companies that have developed new products for advancing engineering technologies in agricultural, food and biological systems and related areas.

The Power and Machinery Division of ASAE will pay special tribute to many of these companies and their representatives on Monday, February 8 at a special Awards Program from 5:00 pm until 6:00 pm. A reception will immediately follow the presentations. All AETC registrants are invited to this very special event.

For AETC '99 information contact:
Jim Hitch, Conference Chair Case Corporation. 545 35th Ave., East Moline, IL 61244-3431
Phone: 309-752-3949; Fax: 309-752-3814; E-mail: <jhitch@casecorp.com>
ASAE Meetings & Conferences, 2950 Niles Road, St. Joseph, MI 49085-9659
Phone: 616-429-0300; Fax: 616-429-3852; E-mail: <hq@asae.org>

101st FIERAGRICOLA

February 10-14, 1999
Verona, Italy

The 101st FIERAGRICOLA, *the International Agriculture and Zootechnics Exhibition* (Verona 10/14 February 1999) is ready to repeat the success of the Centenary year. In 1998 all Exhibition statistics were up on the previous year: 942 exhibitors from 17 different countries, a total surface area of 55 859 square meters, 151 478 paying visitors (over 164 000 if gift tickets and press invitations are included; although these visitors are excluded by the FKM system of auditing Exhibition figures, which VeronaFiere – the only one in Italy – has used for all Exhibitions since 1997).

Over recent years FIERAGRICOLA has upgraded it services in order to meet the needs of the farming and agricultural community, making Zoosystem and Agrimecanica events held every 2 years, alternating with their German equivalents, organized by DLG (Eurotier and Agritechnica).

In 1999 the focus will be on ZOOSYSTEM, *the showcase for Zootechnics, Products and Technology*. This showcase is the meeting of agriculture and industry, and features the most up-to-date breeding techniques (cattle, pigs, birds, rabbits, goats and sheep) used internationally, machinery, plant and technology, hardware and software systems, genetics, artificial insemination, feed and products for environmental protection.

A large part of the conferences, meetings and conventions organized during the 101st FIERAGRICOLA will focus on genetics, market and production globalization, animal well-being, bio-ethics, the quality of production, and the use of natural fertilizers. These subjects have been at the heart of recent interest in agriculture both in the domestic and in international markets, and have led to research and experimentation which have created new products for greater competitiveness.

Vegetable genetics will also feature highly during the Exhibition, not only in the section dedicated to the national *Exhibition of Fruit and Vegetables*, organized in conjunction with the Cesena Research Centre into Vegetable Research and Production (CRPU), where many of Italy's most exciting contributions to vegetable genetics will be on show. Another section of the Exhibition includes Multi-purpose Agricultural Technology featuring Ortosystem, with instruments and tools used in today's market gardening industry, Geodesign, reflecting the increased interest in land and environmental management, and featuring the most important recent technical advances in the area. Gardensystem is a prestige showcase for gardening equipment and products and is targeted on both professional and amateur gardeners. Tecnoirrigua is the part of the Exhibition dedicated to irrigation technology and the proper management of water resources.

I.T. system used in agriculture will also feature prominently in the Exhibition. *Agrimusea* and the *Exhibition of Vintage Tractors* will round up the show side of the exhibition, the latter having proved immensely popular in 1998, with collectors arriving from all over Europe.

The 101st FIERAGRICOLA will include a special section for Training, Research and Services, AGRISERVICE, which provides a direct link between agriculture, the rural world and business which provide a wide range of agricultural services (insurance, banking, software companies). Life in the Country is a specialist showcase which will repeat last year's success. Organized in conjunction with the magazine L'informatore Agrario, this part of the exhibition concentrates on leisure activities in the countryside, the management of small farming businesses, gardening, orchards and farmyard animals. Subcontracting is a specialist showcase which now has a long tradition within the exhibition.

Contact: VERONAFIERE — Viale del Lavoro, 8 · C.P. 525 · I · 37100 Verona, Italy · Tel. +39/045/8298111 · Fax. +39/045/8298288 · Telex 480538 FIEREVR · http: //www.veronafiere.it

9th Acquacoltura Exhibition

February 10-14, 1999
Verona, Italy

VeronaFiere has decided to promote an important international summit, with the participation of the world's leading experts in the field, called "Towards the Year 2000: What's Changing in Fish-farming?". The conference will be part of the 9th ACQUACOLTURA, International Exhibition of fish products, technology and equipment for breeders (Verona, February 10-14, 1999), and has been backed by the European Union, the ministries of Health and Agriculture, the international academic and research community, and professional and trade associations from Italy and abroad. The event will be an opportunity for close examination of topical issues and strategies for the definition of a fish-farming policy for the next millennium.

Contact to: VeronaFiere

21st CIGR Section IV-EurAgEng SIG23, AgEnergy '99 Conference "Energy & Agriculture towards the Third Millennium"

June 2-5, 1999
Athens, Greece

The conference will cover the latest news and developments in Energy and Agriculture in scientific sessions, posters, videos, and special interest group meetings. Get to know your colleagues at evening receptions, an Aegean islands cruise, or a visit to the Acropolis and in the technical study tour.

A wide ranging programme is planned, covering the principal areas in which renewable energy and energy saving technologies can have a major impact on agriculture. Emphasis will be placed on biomass production and biomass energy technologies. Water desalination technologies utilizing renewable energy technologies will also have a special position in the programme.

Focal areas for the conference include:

1. Solar Applications
2. Wind Applications
3. Hydro Power
4. Biomass
5. Energy Saving
6. Energy and the Environment
7. Energy and Agricultural Development Policies

Contact to: Prof. G. Papadakis, AgEnergy '99. Dept. of Agricultural Engineering, Agricultural University of Athens, 75 Iera Odos street, GR 118 55, Athens, Greece.
Tel: +30-1-5294002; 5294209; Fax: +30-1-5294023.

Agritech '99 — The 14th International Agricultural Exhibition

September 5-9, 1999
Haifa, Israel

The Agritech '99 Exhibition will be held at the beginning of September 1999 in International Congress Center of Haifa.

The exhibition is the place to meet and do business with leading agricultural experts from all over the world. The exhibition will cover the most comprehensive and up-to-date agricultural exhibitions, including:

- Water and irrigation
- Greenhouses and horticulture
- Dairy farming, sheep and goats
- Biotechnology
- Seeds & propagation materials
- Vegetables
- Floriculture
- Plasticulture
- Fruits & citrus
- Poultry farming
- Field crops
- Aquaculture
- Machinery & equipment
- Chemical & organic fertilizer
- Veterinary and feeding systems
- Post harvest treatment
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Tel: 972-3-514-2868; Fax: 972-3-514-2881; E-mail: agrinfo@agrtiech.org.il; Website: www.agritech.org.il

Gajendra Singh Achieved ASAE Fellow Status

Gajendra Singh, recently achieved Fellow status in the American Society of Agricultural Engineers.

Singh, a member of ASAE for 22 years, is a professor at the Asian Institute of Technology in Bangkok, Thailand. He was a former president of AAAE (The Asian Association for Agricultural Engineering). He has been serving as a co-editor of AMA since 1978. ■■

Networking for Development

(UK)

by Paul Starkey

This publication derives from a network discussion paper (Starkey, 1992) prepared for the Animal Traction Network for Eastern and Southern Africa (ATNESA) and the West Africa Animal Traction Network (WAATN). That paper followed the author's participation in a workshop on Networking for Low External Input and Sustainable Agriculture held in the Philippines in 1992. At this workshop, 40 network facilitators and coordinators from around the world shared their experiences and discussed ways in which networks could be made more effective. The workshop was arranged by the Information Centre for Low External Input and Sustainable Agriculture (ILEIA), based in The Netherlands. It was hosted by the International Institute of Rural Reconstruction (IIRR), with support from World Neighbors.

The analysis of networks and networking presented in Part 1 derives from the experiences of the African animal traction networks as well as the papers, case histories and discussions of the ILEIA workshop. The workshop planning paper of Moelinono and Fisher (1992) which reviewed experiences of several networks in Southeast Asia was particularly helpful. Further information concerning the many network examples and workshop discussions may be obtained from the proceedings (Alders, Haverkort and van Veldhuizen, 1993) and a related volume prepared by Nelson and Farrington (1994).

Part 2 starts by explaining how the African animal traction networks developed and goes on to discuss some of the lessons learned. Presenting network experiences in this way has involved some inevitable selectivity and oversimplification. The animal traction networks are not offered as models, but as concrete examples of issues, achievements and problems that illustrate the general networking points summarized in Part 1. Further information on these networks can be obtained from the publications and network contacts listed at the end of this book.

This IFRTD book is also available in other languages. A Spanish edition has been prepared in collaboration with the Red Lainoamericana de Tracción Animal (RELATA). The Food and Agriculture Organization of the United Nations (FAO) supported the preparation of a French edition.

105 pages, 6 x 9 inches, softbound

Published by International Forum for Rural Transport and Development New Premier House (2nd Floor), 150 Southampton Row, London WC1B 5AL, United Kingdom
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Robotics for Bio-production Systems

(USA)

Edited by N. Kondo and K.C. Ting

"The purpose of this book is to provide a systematic overview of robotics technologies applied to bioproduction tasks. The special design considerations and unique features of the robots used in various bioproduction systems are discussed. A coverage of robotics fundamentals is presented in a logical sequence, including the major components of manipulators, sensing elements, traveling devices, and reasoning algorithms, to aid the readers in understanding the underlying principles used in designing bioproduction robots. A large number of example robotic systems develped for use in the open field, within controlled environments, and in the food industry are described. The monograph concludes with a presentation of the methodologies of systems approach and economic evaluation."

Main Contents:

Introduction
Robotics for Manipulating Biological Objects
Fundamentals and Basic Components of Robots
Design and Control of Manipulators
Machine Vision
Sensors for Bioproduction Robots
Traveling Devices within Bioproduction Environments
Robots Intelligence
Robots in Bioproduction within Controlled Environments
Robots in Bioproduction in Open Fields
Robots in the Food Industry
System Analysis, Integration, and Economic Feasibility

325 pages, 6 x 9 inches, hardbound

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BACK ISSUES

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(Vol. 28, No. 3, Summer, 1997)

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 28, No. 4, Autumn, 1997)

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Priority in the selection of articles for publication is given to those that —

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d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are printed, double-spaced, under 3,000 words (approximately equivalent to 6 pages of AMA-size paper) ; and those that
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b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
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   iv) body proper (text/discussion) ;
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   vi) bibliography
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e. The data for the graph must also be included.
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g. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
h. Express measurements in the metric system and crop yields in metric tons per hectare (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. When numbers must start a sentence, such numbers must be written in words, e.g., Forty-five workers..., or Five tractors..." instead of 45 workers..., or, 5 tractors.

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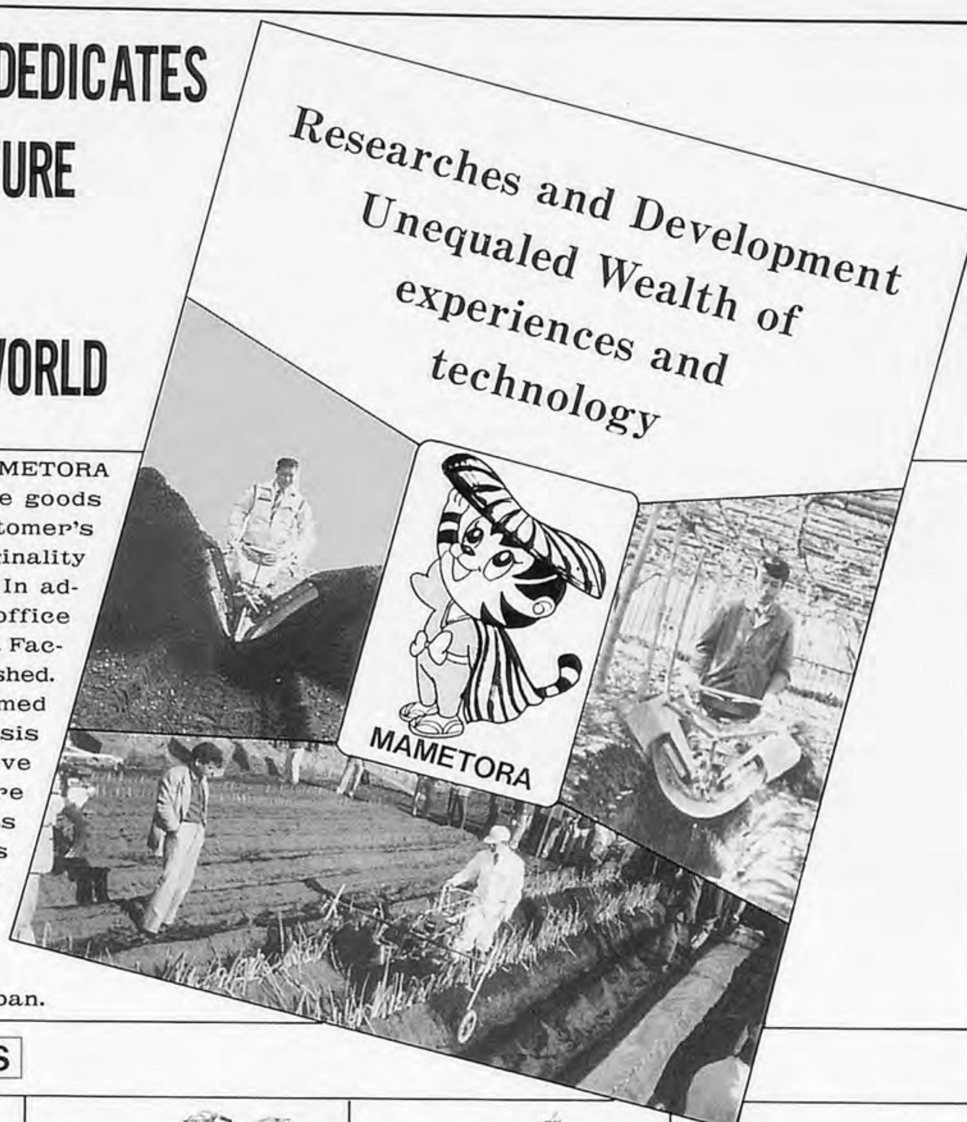

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