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FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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This publication, published quarterly, has an objective to promote agricultural mechanization in developing countries. Its readers consist of so many people in various fields such as farmers, dealers, manufacturers, researchers, government officials, students, etc. not only in Asia but also in the whole world. To enrich contents and to reflect many opinions, we want contributors for **Agricultural Mechanization in Asia" Africa and Latin America.** Articles, comments, investigations, reports and so on will be received with open arms. If you hope to contribute, contact us without delay.

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NEW TECHNOLOGY IN GRAIN POSTHARVESTING

by Ritsuya Yamashita

Professor emeritus of Kyoto University, Professor of Kinki University

This book contains the last lecture of professor Ritsuya Yamashita at his retirement by the age limit, which were summarized from his enormous researches for a long time, and supplementarily recent new technologies of postharvesting. Therefore, topics in this book are extended to all techniques of postharvest processing and a lot of new findings and techniques are described from fundamental studies for their actual applications.

Details are explained especially on property of rice, low cost drying system of rice from the taste point of view, husking, whitening and polishing techniques and dynamic storage. This book is consisted of 9 chapters and 4 appendixes: Chapter 1 Introduction, Chapter 2 Harvesting, Chapter 3 Drying, Chapter 4 Husking, Chapter 5 Whitening and polishing, Chapter 6 Separation and rice mixing, Chapter 7 Storage, Chapter 8 Quality adjusting by moisture control, packing and distribution, Chapter 9 Conclusion (future technique), Appendix-1 Evaluation of rice taste by taste meter, Appendix-2 Numeric color expression by color difference meter, Appendix-3 Example of calculation of drying speed with temperature control and Appendix-4 Equations for respiratory type gas replacement method.

This book covers from processing just after harvesting through adjusting, packing and distribution to possible and necessary future techniques from quality, taste and low cost production of rice points of view.

The author is convinced that this book is surely useful as a guide for technicians, administrators and researchers concerning to the postharvest.

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This is the 86th issue since its maiden issue in the Spring of 1971

EDITORIAL

Season's Greetings to Everyone!

It is almost twenty four years since AMA was started in spring, 1971 with the title of "AGRICULTURAL MECHANIZATION IN SOUTH EAST ASIA," intending to promote communication among world experts that is essential to the progress of agricultural mechanization in developing countries. For these years AMA has continued to play an active part in linking the people concerned and encouraging useful communication.

Nevertheless still a large number of farmers have not been released from the burden of hard labor and poor livelihood. The gap between the poor and the rich is being expanded. The growing power of city consumers is putting down the price of agricultural products, making the trade condition between rural and urban areas more and more unreasonable. In other words cities is putting pressure on rural areas. Even under these circumstances it is great to note that every kind of effort has been made to realize low cost mechanization system fittable to agriculture in developing countries and that large progress was made in some areas. In fact, however, there are still many areas where farmers can hardly purchase even simple implements.

The trend that urban consumers put the pressure on global eco-system including farmers seems not to change its direction. If this situation continues, mankind will fall into a crisis of its existence by the end of 21st century. Agriculture, unlike factory management, is not the industry which can be recovered in a short time. It will be too late when we become aware of the problem. Though difficult situation seems to continue, we will cooperate actively with world associates to realize step by step better life of farmers in developing countries.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1995

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 26, No. 1, Winter 1995

Ballast Optimization of a Front Wheel Assist Tractor

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Abstract

An agricultural tractor was tested in field in order to identify the best of five ballast conditions. A statistical analysis of the test results indicated the best ballast condition among the tested.

Introduction

One of the main objectives of agricultural researchers is to reduce agricultural production costs. Improving the tractor efficiency by means of an adequate selection of the tractor ballast can contribute to attaining this goal.

Previous studies have shown that the dynamic load and the inflation pressure can be selected to ensure an optimum tractive efficiency under all operating conditions (Burt and Bailey; Burt et al., 1983). It was also reported that the maximum tractive efficiency does not necessarily occur at the minimum level of slip required to develop a given level of drawbar pull. A control program was developed by Lyne and Burt (1987) in order to cycle a tire over its operating range of dynamic load and inflation pressure while monitoring tractive efficiency, compute a tractive efficiency response surface for the particular soil conditions and net traction level, and subsequently, determine the dynamic load and inflation pressure for optimum tractive efficiency. For some soil conditions, the difference between optimum and minimum tractive efficiency was found to be over 30%.

Bashford et al., (1985) carried out a series of experiments on a front-wheel assist tractor. The total tractor weight was held constant but its distribution was varied. Performance comparisons were made between four-wheel and two-wheel drive modes, with different front tire sizes in order to change the wheel speed ratio between front and rear wheels. Tests were conducted for an instrumented tractor on concrete and on a tilled clay loam. The conclusions were: a) a wheel speed ratio of 1.01 to 1.05 was near optimum for high tractive efficiency; b) a ballast distribution with approximately 40 to 45% of the total static load on the front axle for the front-wheel drive assist tractor operating on soil or concrete resulted in better tractive efficiencies; c) tractive efficiency was more sensitive to dynamic load distribution when the tractor was operated on loose soil than on concrete.

The objective of this study was to develop a methodology to identify the best ballast condition among several tested.

Procedure

A tractor equipped with a mechanical front-wheel assist was used in the experiments. Its main characteristics are shown in **Table 1**. The tractor was instrumented in order to obtain parameters to evaluate its performance in the field. These parameters were: engine speed N (min^{-1}), drawbar pull P (kN),

Table 1. Main Characteristics of Test Tractor

Item	Characteristic
Cylinder	6
Displacement	6.578 liters
Compression ratio	16.3:1
Air intake	Naturally aspirated
Power and rated speed	66 kW at 2 100 rpm
Front tires	14.9-24 R1
Rear tires	18.4-34 R1
Drawbar height	500 mm
Wheelbase	2 520 mm

Table 2. Ballast Conditions of Test Tractor

Condition	Front (kg)	Weight (%)	Rear (kg)	Weight (%)	Total weight (kg)	Percentage relative to total weight of condition 5
1	2 600	44	3 260	56	5 860	91.6
2	2 400	40	3 570	60	5 970	93.3
3	2 100	35	3 900	65	6 000	93.7
4	2 600	42	3 530	58	6 130	95.8
5	2 600	41	3 800	59	6 400	100.0

travel speed V (km/h), fuel consumption (kg/h), wheel slip S (%) and temperatures (°C) of fuel, intake air, wet and dry bulb, cooling liquid and oil engine.

The engine speed was measured directly from its flywheel. The drawbar pull was determined by force transducers and its value considered as the integrated average along a 40-m standard distance. The rotation of each wheel was measured by an optical transducer and used to obtain the wheel slip. the rolling radius was determined on concrete at zero drawbar pull and used as the basis to calculate drive wheel slip. Fuel consumption was determined by a Pierburg PLU 106 volume flow meter. Temperatures were measured by means of platinum resistance thermometers. The accuracy of the equipments are in accordance with ISO 789/1 standard.

As the engine performance is affected by ambient conditions (pressure, temperature and air humidity), the reduction factor of ISO 2288 Standard was used to calculate the reduced drawbar power.

The tractor performance was evaluated for five ballast conditions **(Table 2)**. These conditions were chosen as to study the effects of tractor total weight and weight distribution on the tractor performance. The fifth condition is the maximum possible ballast condition and the weight distribution for this case is in accordance with Bashford et al., 1985.

Tests were carried out for two gears: reduced fifth because it gives the maximum power for the travel speed range between 6 and 8 kg/h frequently found in agricultural operations and normal second because this is the gear with higher travel speed that results in a slip of 35% assumed as the situation of maximum drawbar pull.

Two parameters were used to compare ballast conditions: the maximum drawbar power PD (kW) at the reduced fifth gear and the dynamic traction ratio DTR observed for the normal second gear calculated as the ratio of the drawbar pull, at 35% slip, to the tractor weight. The engine speed control lever was set in a position to result in the maximum idle speed specified by the tractor manufacturer. By doing this, for each ballast condition the same maximum power can be delivered to the driving axles with the traction efficiency (ratio between the drawbar power and the total power in the driving axles) optimizing by the maximization of the drawbar power.

Tests were conducted on a clay loam soil at the Centro Nacional de Engenharia Agricola. Data were obtained for no-tilled soil. Average properties of the soil for a depth of 15 cm were cone index 1 300 kPa, moisture content of 21% and bulk density of 1.3 g/cm^3.

The experimental procedure was completely randomized with nine replications for each ballast condition for determining the maximum drawbar power, and four repetitions to determine the dynamic traction ratio. Due to the fact that the power is almost invariant within the range 1 950 to 2 050 rpm, it was decided to conduct three replications for each of the engine speeds of 1 950, 2 000 and 2 500 rpm. The Turkey test was used to compare the averages obtained for each ballast condition.

Results and Discussion

The maximum drawbar power average values for the reduced fifth gear are shown in **Table 3** which shows that:

1. At 5% level of probability PD5 (maximum drawbar power for ballast condition 5) was the highest power observed. Even at 1% level of probability it was higher than PD1 and PD3.
2. At 1% level of probability, significant differences in the engine speeds were not observed, as expected. This fact is very important because the experimental procedure was designed to be carried out with constant engine speed.
3. At 5% level, the existence of a worst ballast condition in terms of the drawbar power was not observed.

Table 4 presents average values for the drawbar pull, dynamic traction ratio and wheel slip. As the drawbar is a function of the tractor total weight, the averages are not directly comparable.

The objective is to evaluate the ballast condition 5 in the tractor traction performance and, therefore, the variable drawbar pull was transformed into the dynamic

Table 3. Average Values of Maximum Drawbar Power and Engine Speed for Each Ballast Condition in the Reduced Fifth Gear

Item	Ballast Condition					
	1	2	3	4	5	Average
Maximum drawbar power PD (kN)	43.8 b B	44.2 b AB	43.9 b B	44.1 b AB	46.0 a A	44.4 (2.66%)*
Engine speed N (rpm)	1993 a A	1997 a A	1987 a A	1997 a A	2007 a A	1996 (0.75%)*

Minimum significant difference for PD: 1.60 at 1.95 at 1%
*Coefficient of variation.
Note: Averages followed by the same letter do not differ by Tukey test; small cases refer to 5% level and capital cases refer to 1% level of probability.

Table 4. Average and Values of Drawbar Pull, Dynamic Traction Ratio and Wheel Slip for Each Ballast Condition in the Normal Second Gear

Item	Ballast Condition					
	1	2	3	4	5	Average
Drawbar pull P (kN)	38.1	36.9	38.6	39.0	40.7	38.6 (2.20%)*
Dynamic traction ratio DTR (%)	66.2 a A	63.1 b A	65.5 ab A	64.9 ab A	64.8 ab A	64.9 (2.17)*
Wheel slip S (%)	35.7 a Aa	36.0 a A	35.0 a A	35.7 a A	35.2 a A	35.5 (3.09)*

Minimum significant difference for DIR: 3.08 at 3.92 at 1%
*Coefficient of variation.
Note: Averages followed by the same letter do not differ by Tukey test; small cases refer to 5% level and capital refer to 1% level of probability.

traction ratio. **Table 4** shows the following findings:

1. At 5% level the only significant difference found was that DTR1 is higher than DTR2 characterizing the non-existence of a better or worse ballast condition related to the DTR factor.

2. At 1% level, no significant difference were observed regarding variable DTR.

3. At 1% level of probability, no significant differences were observed in the wheel slip for each ballast condition. This fact is very important because the experimental procedure was designed to be conducted with constant wheel slip.

From **Tables 3** and **4** it may be noted that the measured variables exhibit coefficient of variation of less or equal to 3%, corresponding to a very small relative dispersion and characterizing the experiment as accurate. Regarding the analysis of the effect of ballasting on the tractor performance, this can only be carried out for ballast conditions 2 and 3 corresponding to approximately the same total weight. Not even at 5% level of probability no significant difference was observed for variables PD and DTR.

The best ballast condition was found to be condition 5 because it gave the higher power and a dynamic traction ratio not significantly smaller (at 1 and 5%) than the higher absolute value. This condition is in accordance with the condition suggested by Bashford et al., (1985) regarding the weight distribution. Also, it exhibits a higher dynamic load on the tires.

Conclusions

The methodology of finding out, under field condition, the best among several ballast conditions for a tractor is appropriate. Ballast condition 5 was found to be best because it resulted in a higher power and a dynamic traction ratio not significantly smaller than the higher observed value.

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Tractor vs Power: Projections for Indian Arid Zone

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Abstract

An analysis of the use of tractor and animal power for agriculture in the arid region has shown that about 50% area can be sown by tractor, 18.5% by bullocks and 26.3% by camel. The coverage varies with the number of days of utilities of animals and tractors. Considering both agriculture and transportation the benefit cost ratio for tractor, camel, single bullock and pair of bullocks have been estimated at 1.39, 1.06, 0.85 and 0.86, respectively, for maximum utility. If the operator's cost is excluded, i.e., the owner himself is the operator, the benefit cost ratio for tractor, camel, bullock and pair of bullocks were 1.52, 1.43, 1.3 and 1.07, respectively. The results are indicative of the significance of the animal power in arid regions.

Acknowledgement: The authors are grateful to Dr. J. Venkateswarlu, Director Central Arid Zone Research Institute, Jodhpur for his valuable guidance and constant encouragement in carrying out the study.

Introduction

The 10 districts of the arid zone of Rajasthan, India had a net sown area of 8.13 M ha in 1977-1978 which it was 6.48 M ha in 1956-57. Simulation of data has shown a linear growth rate of 0.98% on the cultivation area (1). The 11th district i.e., Ganganagar, has been excluded because of irrigation facilities.

The region receives scanty rainfall (average 310 mm) and the distribution pattern is quite unpredictable. The moisture in the soil is available for a very short period and this limits the sowing time. The general practice is to combine the two operations, viz. field preparation and sowing and thus it enables the farmers to cover larger area in shorter time. As the average holdings are high, it is quite obvious that the mechanical means, i.e., tractor would prevail on the traditional utilization of animal power. The number of tractors in 1977 was 14 759 and it was projected that in the year 2000 there would be 80 000 units. Recurring droughts have checked the growth of animals, particularly bullocks. There were 362 210 bullocks (over three years age) in 1988 while the number was 747 853 in 1977. The camels seem to survive because of their hardy nature which population was 517 282 head in 1988(3).

The use of animal power has been a part and parcel of rural life. The usage varies from place to place. In a comparative study of two villages in Delhi and West Bengal, it was found that in Delhi 14.9% energy was supplemented by animal power while in West Bengal, the animal sources provided 40.4% of the energy requirements in agiculture (4). The energetics of crops grown by bullocks and tractor power has been compared for village Islamnagar in the district of Bhopal which indicates that with tractor the required energy is almost double compared to needful energy if the crop is raised by bullock power (5). The results are interesting if energetics are considered to be important factor for sustained growth. The scope of tractorization in arid zones has been analyzed by Gajja et al., (6). Unfortunately, the relative contribution of animal and tractor in arid zone cultivation has not been quantified by actual experiments, although, the total available power of animal and tractor were computed and compared which indicated that the available power was only 10% of the total power needed for the year 1977 (7). On the other hand, while analyzing the draught power for use in arid Rajasthan, it was found that the tractor energy was two to three times more than the requirement. These discrepancies arise due to the non-availability of actual energy parameters for the arid region and when evaluation is performed on the basis of superposition of available basic parameters from different sources, such variations are indicated. In view of this, a fresh attempt has been made to evaluate the relative potential of animal and tractor power in the arid region.

Resource Availability

The general usage of the tractor besides agricultural operations like sowing, threshing and chaff-cutting are for transportation of agricultural produce, materials for construction and sometimes to carry persons during local weddings. The inter-state transfer during off-season is predominant. Tractors have been reported to go far off to neighbouring states to keep the machine busy during off seasons and to fetch profits.

The animals are also employed for agricultural operation, transportation of agricultural produce and construction materials. However, their efficiencies are limited. While the animals are susceptible to health hazards and an amount of risk is there, the initial investment is lower compared to that of tractor. For animals, the fodder is to be supplemented from neighbouring states, particularly during drought; while for tractors, diesel is required which is getting rarer and dearer. The tractors may cause damage to soil texture due to deep ploughing followed by erosion. Nevertheless, it is the only mode to cover larger areas in limited time and growth patterns indicate its utility. Therefore, while analyzing the resource availability in terms of tractors and animal power for arid zone agriculture, it is important to consider all these aspects.

Table 1. Availability of Tractors, Bullock, Buffaloes and Camels in the Arid Region

Power source	In arid region including Ganganagar (number)	In Ganganagar only (number)	Av. Power/Unit source (hp)
Tractors	46 982	22 879	35
Bullocks	362 210	69 736	0.5
Buffaloes	31 409	834	0.5
Camels	517 282	103 180	1.0

The total number of tractors, bullocks, buffaloes and camels available in arid zone and Ganganagar are shown in **Table 1**. The power of these sources are also indicated.

The total number of tractors are the projected values for 1992 (2). Assuming that about 11 000 tractors cross towards the arid region from neighbouring Ganganagar and other regions, the total number of tractors available in this region during kharif season is assumed to be 35 000. The number of bullocks and buffaloes are 292 474 and 30 575, respectively and that of camels is 414 101 (3).

Potential of Draught Power

For Tractors

To evaluate the potential of available draught power in the arid region, particularly in the kharif season, several assumptions are made which are as follows.

1. The total number of useful days of utilization during the kharif season are 10 for pearl millet sowing and 3 days for moong bean, moth bean and cluster bean. This extended time is in view of the fact that normally there is rainfall in a small pocket and thus it gives chance for tractor mobilization to another place when the other pocket gets rain. It is also assumed that work is carried out from tractor for 20 h/day during sowing period to complete the agricultural operations considering the limited moisture availability.

2. For transportation purposes, it is assumed that the tractor can be employed for 740 h/year with an average of 8 h/day working and diesel consumption of 3.5 ℓ/h.

3. For bajra sowing, on an average it is assumed that one hectare is covered in two hours which includes time taken for field to field transfer. The tractor is used for 260 h for sowing, 300 h for chaff-cutting and 190 h for threshing operations.

For Animals

1. On an average, bullocks can work 8 h/day covering an area 0.45 ha daily with single plough. The camels cover 0.9 ha with *dufan* and 0.45 ha with single plough (**Figs. 1** and **2**). A pair of bullocks and camel are shown when employed for sowing operation while in **Fig. 3** the camel is shown with single plough. The total number of useful working days for cultivation are assumed to be 7 days. However, for comparison purposes a separate evaluation for 13 days of useful operation has also been considered in case there are intermittant rains and thus provides an opportunity to use animal power for an extended period.

Fig. 1 Sowing operation using camel with *dufan*.

Fig. 2 Sowing operation using a pair of bullocks.

Fig. 3 Camel with a single plough.

2. Some 90% of the bullock and buffaloes above 3 year old are employed for sowing operation while for camels it was assumed that 50% of their population is engaged in agricultural operations.

3. The bullocks and camels are used for transportation for approximately 1 400 and 1 700 h in a year, respectively. **Figs. 4, 5** and **6** show camel and bullocks when used for transportation purposes.

4. On an average, each bullock consumes fodder and feed worth Rs. 30 while camel requires fodder and feed of Rs. 40. Some part of the fodder is met from agricultural fields.

Based on the above assumptions, the area covered by using tractor and animal power were

Fig. 4 Camel cart for transportation.

Fig. 5 Single bullock cart.

Fig. 6 Cart with a pair of bullocks.

computed for two cases **(Table 2)**.

In case II above, all the modes used for 13 days while in case I, the tractors were used for 13 days and animals for only 7 days. Thus, the area covered by these various sources vary from 6.735 mha to 8.66 mha depending upon the number of days of utility of animal power for agricultural operation from seven to 13 days.

Considering that the net sown area was 9.2 mha, it is clear that under the condition of maximum utility of draught power, 49.45% area is covered by tractor, 18.48% by bullock and 26.27% by camels and thus 5.8% area need to be covered by either broadcasting oilseeds or by more tractor inflow or leaving the land fallow. If 50% of

Table 2. Field Coverage Through Different Draught Power Sources

Mode	Area covered (M ha)	
	Case I	Case II
Tractor	4.55	4.55
Bullock and Buffaloes	0.90	1.7
Camels	1.304	2.41
Total	6.735	8.66

the camel population is attached to *dufan* and 50% use single plough, the total sown area will be 8.07 mha leaving 12.2% uncovered by these sources.

Economics Consideration

Cost Estimation of Various Draught Power Sources

The cost of using these different sources of power has been evaluated with the following considerations:

The cost of the tractor is assumed to be Rs. 160 thousand and that of bullock and camel as Rs. 4 000 and Rs. 8 000, respectively. The salvage value is taken as 10% of the initial cost of sources of power. The working life of tractor, bullock and camel is assumed to be 10 years, 8 years, respectively. The working hours of tractor is assumed to be 1 500 h/year whereas for the bullock and camel, it is 1 500 and 1 800 h/year, respectively. In this evaluation, the utilization for both farm work and transportation was considered.

The depreciation and interest per hour have been calculated by using the following simple formulae:

$$D = \frac{0.9C}{L \times H} \text{ (in Rs./h)}$$

$$I = 0.55C \times \frac{i}{H} \text{ (in Rs./h)}$$

Where
D = Depreciation
C = Initial cost
L = Life in years
H = Working hours per year

i = Rate of interest (18%)

The maintenance cost for the bullock and camel was assumed to be Rs. 30 and Rs. 40/day, respectively. The maintenance cost/h was calculated by multiplying the daily expenditure by 365 and dividing it by working h/year. The operator's cost was assumed to be Rs. 25/day for 8 h of work.

For tractors, the repair and maintenance cost were calculated at 6% each and insurance at 2% of the initial cost. The fuel cost was assumed at 3.5 ℓ/h at a cost of Rs. 5.62 with lubricant cost at a rate of 30% of fuel cost. The wage of operator was assumed at Rs. 40/day (for 8 h of work). The cost/h of these different sources of draught power are computed and shown in **Table 3**. The tractor's cost is about Rs. 59/h while the cost of bullock and camels for each hour of use are Rs. 11 and 12, respectively.

The cost of draught power sources viz. tractor, bullock and camels for two cases: i) with operator's cost and ii) without operator's cost (considering that the farmer himself) does the work as computed and shown in **Table 4**.

With the operator's cost, the use of camel is cheaper (Rs. 106/ha) compared to that of the tractor at Rs. 134/ha. Considering that the farmer himself operates the animal draught power, the cost is reduced to Rs. 80/ha for the camel and Rs. 142/ha for a single bullock. Generally, the tractors are hired to do the sowing operation within a limited time. On average, the cost of hiring of tractor for sowing operation was Rs. 115/h.

Table 3. Cost Calculation for Various Sources of Power and Equipment

Item	Tractor	Culti-vator	Tractor trailer	Bullock	Camel	Bullock cart	Camel cart
Initial cost Rs.	160 000	8 000	18 000	4 000	8 000	5 000	8 000
Service life, h	15 000	6 000	6 000	12 000	18 000	8 000	8 000
Depreciation, Rs/h	9.60	1.20	2.70	0.30	0.40	0.56	0.90
Interest on investment Rs/h	10.56	1.98	1.78	0.26	0.44	0.32	0.47
Taxes, shelter & insurance @ 2% Rs./h	2.13	0.40	0.36	—	—	—	—
Repair & Maintenance @ 6%, Rs/h	6.39	1.20	1.08	7.30	8.11	0.21	0.28
Cost of diesel @ Rs. 5.62/ℓ	19.67	—	—	—	—	—	—
Cost of lubricant @ 30% of diesel cost	5.90	—	—	—	—	—	—
Wages of labour Rs/h	—	3.12	3.12	3.12	3.12	—	—
Wages of operator Rs./h	5.00	—	—	—	—	—	—
Cost Rs/h	59.25	7.90	9.04	10.98	12.07	1.09	1.65

Table 4. Cost of Using Draught Powers

Source			Rs/h	Rs/ha
Tractor	(i)	with operator's cost	67	134
	(ii)	without operator's cost	62	124
Camel	(i)	with operator's cost	12	106
	(ii)	without operator's cost	9	80
Bullock (Single)	(i)	with operator's cost	11	195
	(ii)	without operator's cost	8	142
Bullock (Pair)	(i)	with operator's cost	19	168
	(ii)	without operator's cost	16	142

Table 5. Annual Benefits from Different Power Sources

Power sources	Benefit from transport, Rs.	Benefit from agriculture, Rs.		Total benefit Rs	
		Case I	Case II	Case I	Case II
Tractor	47 000		157 280		204 280
Camel	16 000	11 340	21 000	27 340	37 000
Bullock single	8 750	5 670	10 530	14 420	19 280
Bullock pair	13 200	11 340	21 000	24 540	34 225

Annual Benefits

Assuming the tractor, camels and bullocks were employed for transport work for 750, 1 700 and 1 400 h a year, respectively, and the net daily earnings were Rs. 500 from tractor, Rs. 75 from camel, Rs. 50 from single bullock and Rs. 75 from pair of bullocks, the benefit in a year will be approximately Rs. 47 000 from tractor, Rs. 16 000 from camel and Rs. 13 200 from a pair of bullocks.

The cost of cultivation of pearl millet can be assumed as Rs. 1 000/ha and the gross returns about Rs. 2 800/ha. Thus the profit/ha is about Rs. 1 800. The annual benefits from agricultural operations is obtained by multiplying the profits/ha by the area sown. In the case of the tractor, the average land holding of tractor owner farmer is assumed to be 50 ha. The benefits from 50 ha are Rs. 70 000 from foodgrains at the rate of Rs. 1 400/ha and Rs. 60 000 from chaff-cutting the dry matter of his own land. From the rest of the 80 ha the benefits are accrued by hiring at the rate of Rs. 230/ha (the net profit being Rs. 96/ha). From threshing operations gross benefits are accrued by hiring at the rate of Rs. 110/h for 90 h (net profit being Rs. 51/h). Thus earnings from hiring charges for chaff-cutting will be Rs. 15 000 approximately. The net benefits are given in **Table 5**.

Annual Cost

The cost of using tractor, camel, single bullock and pair of bullocks for transport purposes in Rs/h, was estimated at Rs. 68, 14, 12 and 20, respectively. The cost incurred on transport can be obtained by multiplying these values by annual hours of use for past work. The costs incurred on

Table 6. Annual Cost on Various Power Sources

Power sources	Cost on transport, Rs.	Cost on agriculture, Rs. Case I	Cost on agriculture, Rs. Case II	Total cost Rs Case I	Total cost Rs Case II
Tractor	51 000	—	96 000	—	147 000
Camel	23 800	6 315	11 685	30 115	35 485
Single bullock	16 800	3 150	5 850	19 950	22 650
Pair of bullock	28 000	6 300	11 700	34 300	39 700

Table 7. Benefit-cost Ratio of Various Power Sources

Power Source	B-C ratio with operator's cost	B-C ratio without operator's cost (owner himself is the operator)
Tractor	1.39	1.52
Camel		
(i) Case I	0.91	1.32
(ii) Case II	1.06	1.43
Single bullock		
(i) Case I	0.71	1.23
(ii) Case II	0.85	1.30
Pair of bullock		
(i) Case I	0.71	0.99
(ii) Case II	0.86	1.07

agricultural operations are obtained by multiplying the sown area by Rs. 1 000 (input cost/ha). For tractor, in addition to the above, the cost for 160 h of sowing at the rate of Rs. 67/h, 90 h of threshing at the rate of Rs. 59/h and 300 h of chaff-cutting at the rate of Rs. 100/h are also included. The details of the costs incurred are given in **Table 6**.

Benefit-cost Ratio

The benefit-cost ratio of using tractor, camel, single bullock and pair of bullocks for agricultural and transport work were estimated at 1.39, 1.06, 0.85 and 0.86, respectively, for maximum utility. If the operator's cost is excluded, i.e., the owner himself is the operator, the benefit-cost ratio for tractor, camel, single bullock and pair of bullocks amounts to 1.52, 1.43, 1.3 and 1.07, respectively. The benefit-cost ratio are given in **Table 7**.

Other Aspects

It may be mentioned that for using tractors, the diesel consumption for agricultural operations will be 5.201×10^7 ℓ while for transportation it will consume 8.4×10^7 ℓ diesel. A bullock will consume 15 kg fodder and a camel will consume 25 kg fodder. The total quantity of fodder consumed will be 5.38×10^9 kg.

The total number of animal (bullock and buffaloes above 3 years of age) are 4 393 620. The quantity of dung available will be about 3 148 960 kg with 80% collection efficiency. If this dung is used in biogas plants, it has a potential to produce 115 918 m^3 of biogas which is equivalent to 544 582 kWh of electricity or 433 533 kg of firewood or 71 869 ℓ of kerosene. In addition, 755 750.4 kg of organic manure could also be obtained, which is equivalent to 11 336 kg nitrogen. For comparing the different draught power sources, it is important to carry out a detailed energy audit for evaluating the energetics vis-â-vis economics considering the availability of resources and their proper utilization. The energy auditing requires some basic energy parameters, these need to be estimated for the arid regions and then the energetics and economics could be matched to provide information necessary for planning with a view to achieving sustained and comprehensive growth.

Conclusion

The study has shown that in the arid region about 50% area can be sown by tractors and 45% by animals, i.e., camel and bullock when used to maximum utility.

The benefit-cost ratio analysis for both agriculture and transportation indicates the importance of animal power, particularly when the owner himself is the operator. Thus, the study implies that although the tractor power dominates, the significance of animal power cannot be ignored.

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Measuring the Drawbar Performance of Animals and Small Tractors

(II) Small Tractors

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Abstract

Using the pull-out test rig described in Part I of this paper and other locally made equipment, the fundamental parameters specifying tractor drawbar performance were measured for two tractors working on firm and soft soils (both dry and wet). The results are presented in a graphical form.

Introduction

The use of two-wheeled type hand or walking tractors for drawbar work in wet-land rice cultivation has been increasing in Asian countries. If field performance of such tractors is to be optimized — for example, by choosing suitable tractor weight, the correct size of implement for the available tracotr power or the correct gear for a good fuel economy — it is necessary to obtain tractor performance data under field conditions.

However, the performance data currently available are not suitable for these purposes because they are measured and expressed in such a way that they only present the performance of the transmission and of the combined performance of tractor and implement. To gain an understanding of the factors affecting the performance of the tractor, it is necessary to measure the fundamental parameters — such as drawbar pull, travel speed, drawbar power, wheel slip, and fuel consumption at various loading conditions.

This paper describes the method and results of testing the drawbar performance of small tractors, working on firm and also soft, wet soil, using the pull-out rig as a loading and measuring device (Pudjiono and Macmillan, 1992). This work is part of the programme of the development of locally made equipment for teaching and research in agricultural engineering and development technology (Macmillan, 1991).

Test Equipment and Methods

Tractors

Two walking tractors were tested in this experiment. One was a Howard brand powered by a gasoline engine of 9 kW nominal capacity; it had three forward gears. During the test the rotavator, which was fitted to the tractor, was lifted off the ground. The rear of the tractor was supported by a small pneumatic wheel.

The other was a Kerbau Besi brand tractor, which is manufactured in Indonesia to an IRRI design. It has a 5.6 kW Kubota diesel engine and is equipped with fast and slow ratios vee-belt driving a chain transmission. For testing with ballast, two metal blocks were mounted on its engine frame.

In testing on firm surfaces, the tractor ran on pneumatic wheels with a rim size of 5.00-12, and a rolling radius of 0.250 m; the pressure in each tyre was 170 kPa. With testing on soft surfaces, these wheels were replaced with cage wheels 0.70 m in diameter and 0.500 m in width.

The rear of the tractor was supported by a rectangular wooden skid when tested on the dry-cultivated and the flooded conditions; on all other surfaces, it was supported on a small 0.250 m diameter pneumatic wheel.

Both tractors were instrumented to measure the drawbar performance parameters, viz. drawbar pull, wheel slip, travel speed, and fuel consumption.

Other details of the tractors are as shown in **Table 1** and in Pudjiono (1988).

Table 1. Experimental Conditions

Surface type	Surface condition	Transmission setting	Wheel equipment	Tractor weight	Results
Howard Tractor					
Bitumen road	—	1st gear	Pneumatic tyres	With rotavator	Fig. 3
Kerbau Besi Tractor					
Bitumen road	—	Slow	Pneumatic tyres	No ballast	Fig. 4
			,,	With ballast	,,
	—	Fast	Pneumatic tyres	No ballast	,,
			,,	With ballast	,,
Dry field	Uncultivated	Slow	Pneumatic tyres	No ballast	,,
			,,	With ballast	,,
	Cultivated	Slow	Cage wheels	No ballast	Fig. 5
			,,	With ballast	,,
Flooded field	Uncultivated	Slow	Cage wheels	No ballast	,,
			,,	With ballast	,,
	Cultivated	Slow	Cage wheels	No ballast	,,
			,,	With ballast	,,

Test Equipment

Test rig — The 'pull-out' rig described in Part 1 of this paper was used to generate and measure the draught load necessary to explore the drawbar performance of the tractors under variable loading conditions. The rig was mounted on the three point linkage of a stationary four-wheel (anchor) tractor, which was located at one end of the test area.

The draught load was applied to the drawbar of the test tractor, as it moved across the test area, by means of a cord that was unwound from the drum which was also mounted on the brake shaft. This draught load was varied by the operator adjusting the clamping force of the brake pads on the disc brake and was measured as a reaction at the brake pads using a hydraulic force-cell mounted on the rig frame.

Hydraulic force-cell — While any type of force cell could be used, a 38.1 mm cylinder hydraulic cell and associated pressure gauge were chosen for this work. This cell was calibrated by plotting its force readings against those obtained from an Instron testing machine. The results **(Fig. 1)** indicate some hysteresis in the hydraulic cylinder but it proved satisfactory for this work.

Digital counter and timer — A combined digital counter and timer, powered from four dry cells, was built and used to measure and display fuel flow, wheel revolutions, and time. Simultaneous measurement of the data, taken over a known distance, was made by the tractor operator using a single start/stop switch. This gave readings from which travel speed, fuel consumption rate and wheel slip could be calculated.

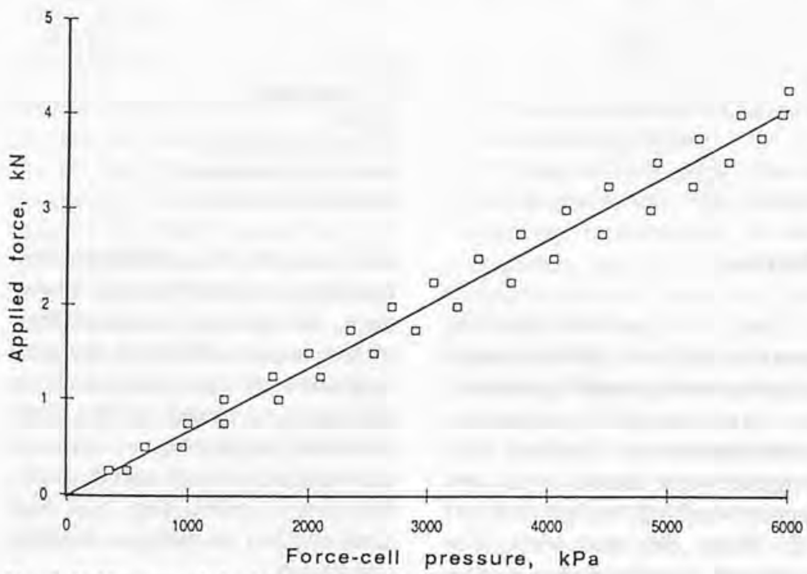

Fig. 1 Calibration of the force-cell.

Wheel revolution counter — The method used to determine wheel slip involves the measurement of wheel revolutions over a fixed distance for load and no-load runs. For this purpose, a pulse generator was built by mounting a small triggering magnet in a shaft mounted on bearings in an aluminium housing clamped to the body of the tractor. The shaft was connected by a flexible coupling to, and driven by, the tractor transmission at a point where there is a fixed ratio to the wheels.

A 'Hall Effect' switch mounted in the housing close to the magnet generated one pulse per revolution of the shaft; the signal was sent via cable connector to the digital counter. By counting the wheel revolutions and knowing the fixed transmission ratio, the accuracy of the counting system was confirmed.

Fuel flow meter — A Keromate flow meter (Model LS 4051), with a rated output of two pulses/mL, was chosen for measuring the fuel consumption of the tractors. This meter, which is specified as being capable fo measuring fuel flow 0.20 L/h (0.056 mL/s), covers the minimum flow rate of a walking tractor.

For the diesel engine, the meter was connected between the fuel tank and the injection pump; the return fuel from the injector was directed to the outlet line of the meter to avoid double counting of the return fuel. For the gasoline engine, the meter was fitted between the fuel tank and the engine carburettor.

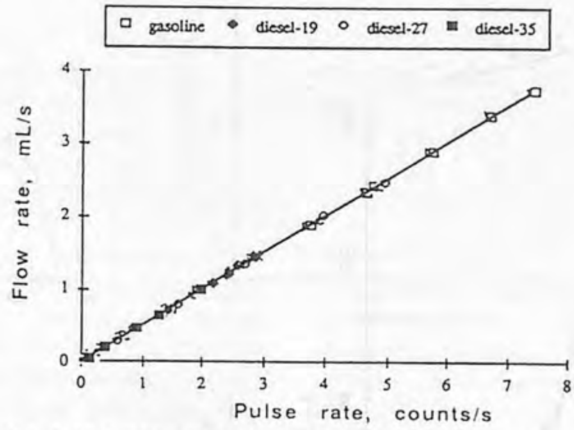

Fig. 2 Calibration of the Keromate fuel meter at various temperatures, °C.

The meter was calibrated using a burette and a stop watch, when measuring diesel fuel and gasoline at flow rates from 0.015 mL/s to 3.7 mL/s and at ambient temperature (19°C) for both fuels, also at 27° and 35°C for the diesel. The flow rate values were plotted against the pulse rates observed on the digital counter and gave the relationship shown in **Fig. 2**.

This instrument measured the fuel flow consistently. However, when used for measuring low flow rates, it is necessary that the measurement be made for a sufficient time to avoid the error associated with the meter least count. This problem was experienced in some conditions during the field experiment, i.e., when measurement was made with the tractor in the fast gear.

Test Procedure

After warming the engine, it was adjusted to maximum governor setting and the tractor was driven over the test surface for the fixed test distance (20 m) under zero drawbar load, giving a defined zero wheel slip. This procedure was then repeated for the tractor running under various drawbar loads provided as the cord, attached to the tractor drawbar, was being unwoud from the drum of pull-out rig. The draught load was set and observed from the latter.

Measurements were made of the wheel revolutions, fuel consumption and elapsed time by activating the digital counter while trvelling over the test distance. The test was repeated by increasing the load in steps until the maximum drawbar pull of the tractor was reached, i.e., when the tractor wheel-slip was excessive or when its engine stalled.

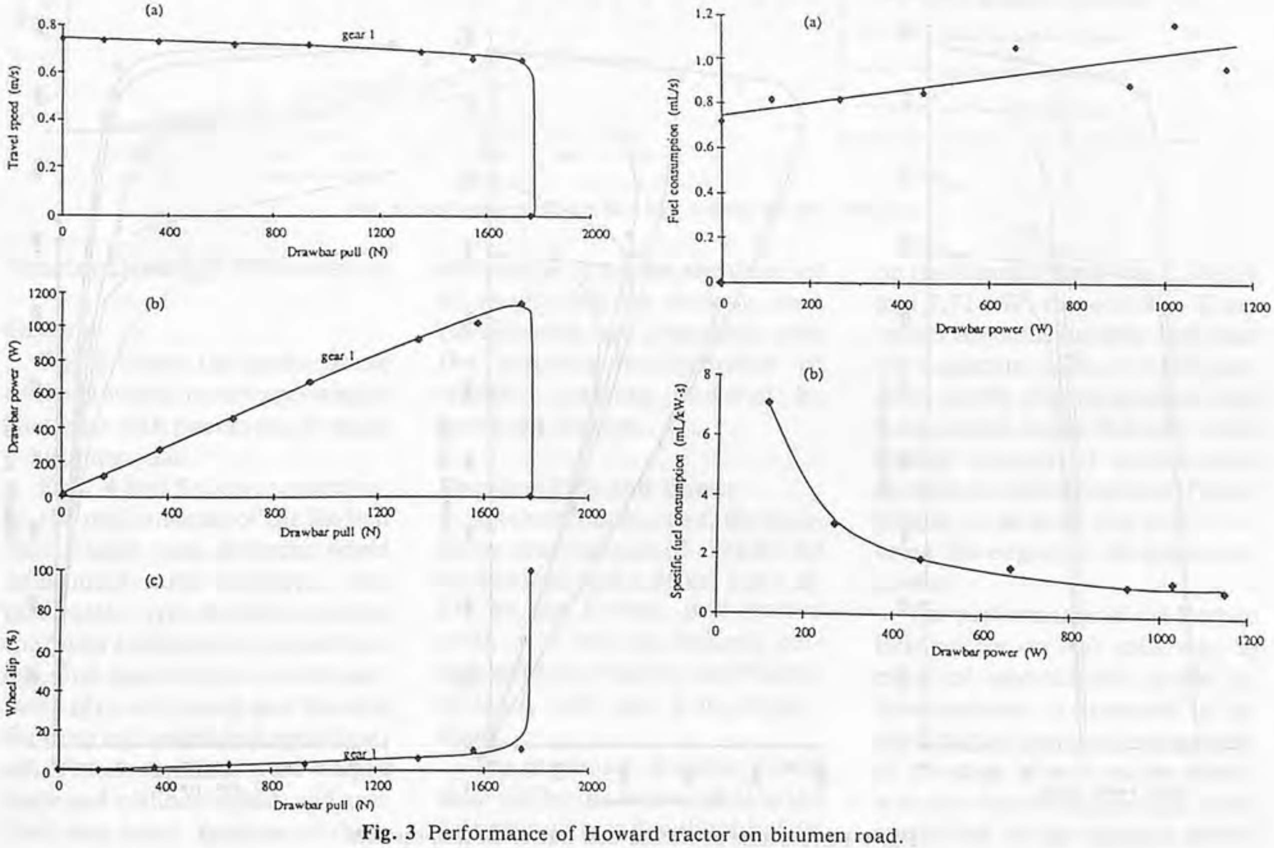

Fig. 3 Performance of Howard tractor on bitumen road.

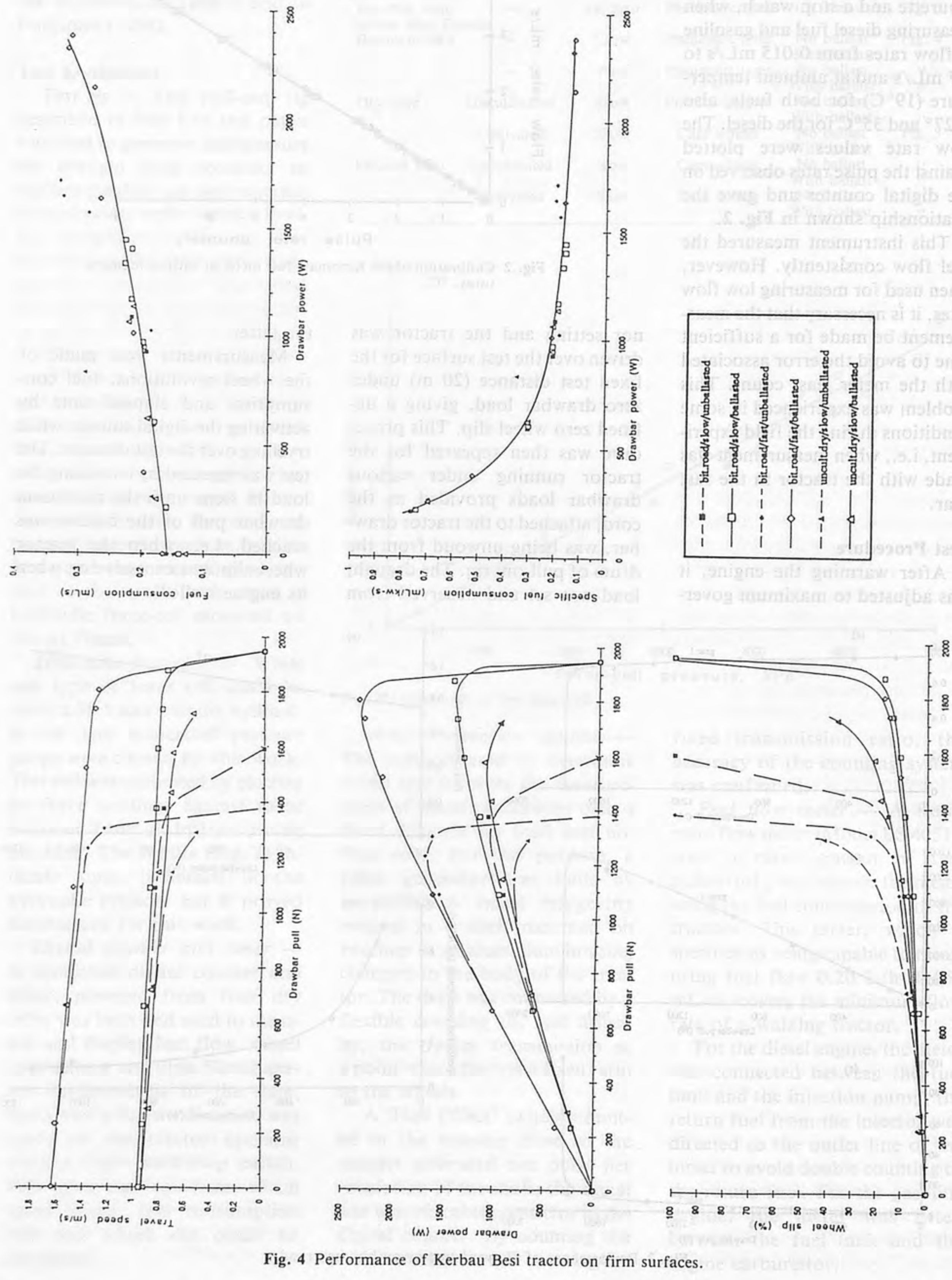

Fig. 4 Performance of Kerbau Besi tractor on firm surfaces.

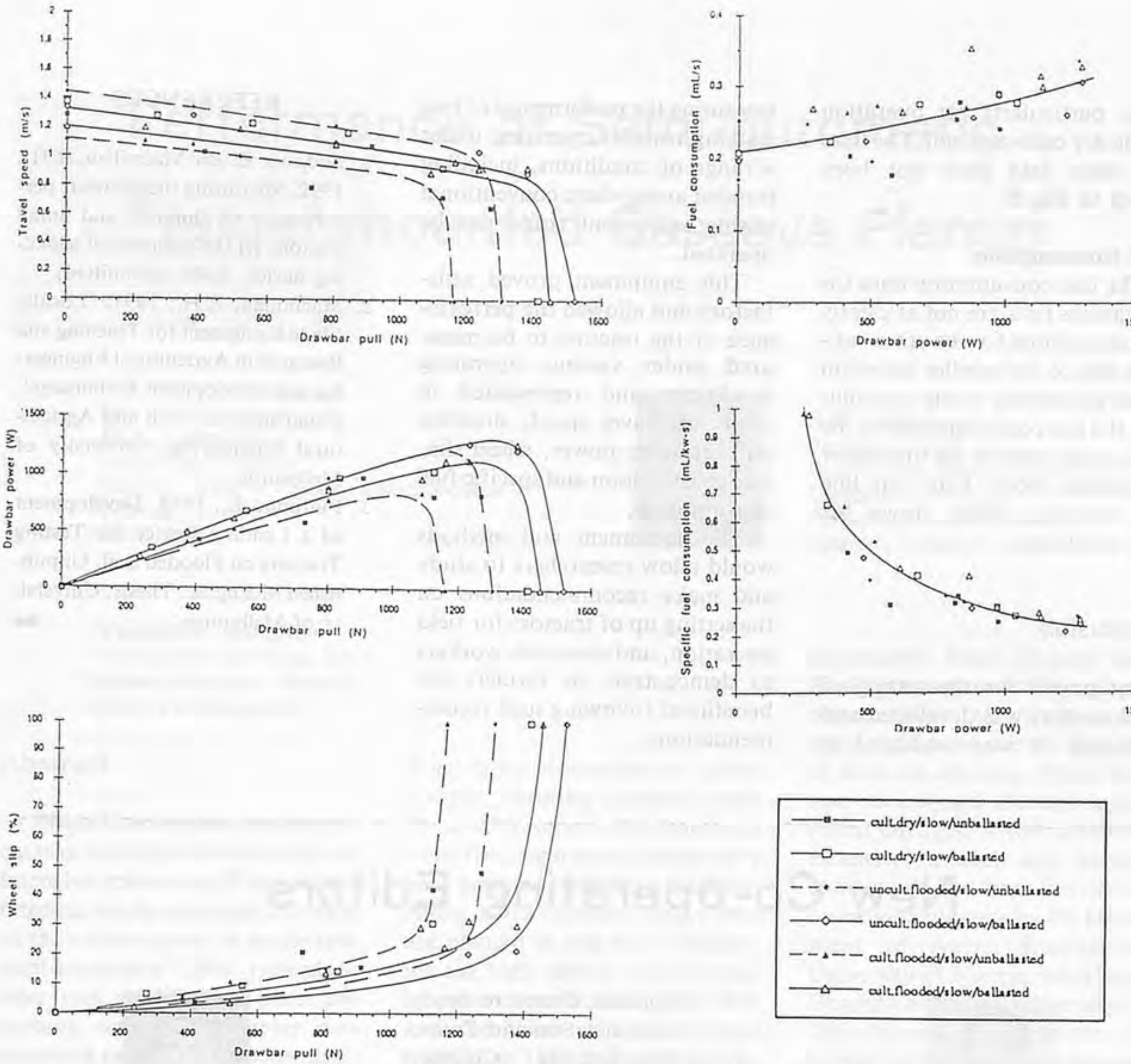

Fig. 5 Performance of Kerbau Besi tractor on soft surfaces.

Tractor Drawbar Performance

General

Fig. 3 shows the performance of the Howard tractor operating in first gear with pneumatic tyres on a bitumen road.

Figs. 4 and **5** show, respectively, the performance of the Kerbau Besi tractor with different wheel equipment and surfaces, viz. pneumatic tyres on firm surfaces (bitumen road and dry uncultivated), and cage wheels on soft surfaces (dry cultivated and flooded for both cultivated and uncultivated). Other variables were weight (with and without ballast) and gear (fast and slow). Because of these differences in set-up, the three set of results are not directly comparable, but are consistent with the expected performance of wheeled tractors powered by governed engines.

Drawbar Pull and Power

On the bitumen road, the maximum drawbar pull of 1.78 kN by the Howard and 1.95 kN and 1.59 kN by the Kerbau Besi tractor (with and without ballast) corresponded to traction coefficients of 0.67, 0.66 and 0.56, respectively.

The maximum drawbar power achieved by the Kerbau Besi in the fast gear with and without ballast on the bitumen road was 2.38 kW and 1.71 kW, respectively. These values are considerably less than the maximum capacity of the engine, partly due to traction and transmission losses, but also to the limited number of transmission settings available and insufficient ballast to so load the tractor to bring the engine to its maximum power.

The performance of the Kerbau Besi tractor on soft soils was, as expected, also inferior to that on firm surfaces. It appeared to depend on the degree of engagement of the cage wheels in the soil. It was also more variable due to the variability in the surface conditions, particularly for operation on the dry cultivated soil. The lines for these data have not been drawn in **Fig. 5**.

Fuel Consumption

The fuel consumption data for the various tests are not as clearly defined as those for the other variables due to the smaller variation in this parameter, to the variability in the test conditions and to the least count error in the fuel meter mentioned above. Only one line has, therefore, been drawn for each condition.

Conclusion

Equipment for the testing of small tractors was developed and calibrated. It was evaluated in measuring the performance of two walking tractors operating under a range of conditions, including flooded areas where conventional testing equipment could not be operated.

This equipment proved satisfactory and allowed the performance of the tractors to be measured under various operating conditions and represented in terms of travel speed, drawbar pull, drawbar power, wheel slip, fuel consumption and specific fuel consumption.

The equipment and methods would allow researchers to study and make recommendations on the setting up of tractors for field operation, and extension workers to demonstrate to farmers the benefits of following such recommendations.

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(Continued on page 79)

Performance of Semi-automatic Tractor-mounted Cassava Planter

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Abstract

Ridge forming and planting of cassava cuttings (setts) are labour intensive operations. This necessitated the study into mechanization of the cassava crop. A single-row semi-automatic 'Ellis' transplantater was modified to plant the cassava setts. The planter was mounted on the three-point linkage of a 70-hp tractor. With easy maneuverability, it could operate at an average speed of 4.39 km/h with a field capacity of 0.39 ha/h and field efficiency of over 60%. The planter required a crew of 4 persons to operate it continuously.

Introduction

It is estimated that, on global basis, cassava is planted on an area between 15 and 20 million ha with annual production of between 110 and 120 million t. Over 300 million people in the tropics consume cassava. The starch extracted from cassava is an important industrial raw material.

Mechanization of cassava in developing countries is quite meagre. Planting is mostly done by hand. In some Latin American countries, sugarcane planters have been adopted to cassava planting. About 10-12 thousand casava setts are planted in one ha. Considering the high labour requirements in cassava production, the first and the third authors initiated research in 1981 to design and develop a two-row, semi-automatic cassava planter suited to Nigerian conditions. It was found from the literature that earlier efforts to design cassava planters included the work by Monteiro (1963), Wahab et al., (1977) and Odigboh (1978).

During the Green Revolution era (1979-85) in Nigeria, a few thousands of semi-automatic transplanters were imported from Italy by the Federal Government and supplied at subsidized rate to the farmers/cooperatives. However, these transplanters did not meet with the approval of the paddy farmers.

Cassava is an important food crop and industrial raw material for Nigeria. It is vegetatively propagated from cassava setts. Healthy cassava cuttings (stems) obtained from plants which are 6 months or older are cut into setts of 20 to 25 cm long. From literature review and through institutional linkages, it was noted that extensive research and development work had been carried out on cassava planters by the Department of Agric. Engineering, University of Nigeria, Nsukka and Obafemi Awolowo University, Ile-Ife in Nigeria. Unfortunately, due to high initial cost, the commercial manufacture of these machines could not be initiated. With the support of the National Centre for Agricultural Mechanization, a project was initiated to investigate the feasibility of modifying the imported semi-automatic transplanters lying unused in the country to use them for cassava planting by the first and second authors.

Agro-technical Considerations

To effect a vertical placement of cassava setts, at the point of release of the sett from the grab, the peripheral speed (V) of the grab's centre should be equal to the forward speed (Vm) of the machine. By taking into account the driving wheel slippage, the relationship could be written as follows:

$$Vm = (1 + \frac{S}{100}) V = \frac{\pi DN}{60} \quad ...(1)$$

Where:

D = Diameter of the grab disk (m)

N = Speed of the grab disk (rpm)

S = wheel slippage (10-12%)

Vm = peripheral speed of driving wheels (m/sec)

Vb = peripheral speed of the grab disk (m/sec)

Under these assumptions, the horizontal component of the resultant sett speed is theoretically equal to zero. Proper synchronization of the opening of the grabs is vital for correct placement of setts in the soil. Premature release of the sett from the grab results in tilting the sett in opposite position to the direction of forward travel. On the other hand, delayed release of the sett results in tilting the sett towards the direction of forward travel.

Covering of the cassava setts with soil should coincide the opening of the grabs. This sequence ensures a firm setting of the cassava setts in the soil. The press wheels ensure proper soil compaction and gripping of the setts.

Traditionally, setts are planted at an angle of 45° with the horizontal or in a vertical position.

Constructional Features and Operation of Semi-automatic Planter

The planter comprises a hopper, a metering disk with grabs, driving-cum-press wheels, operator seat and covering device consisting of two disk-type ridgers.

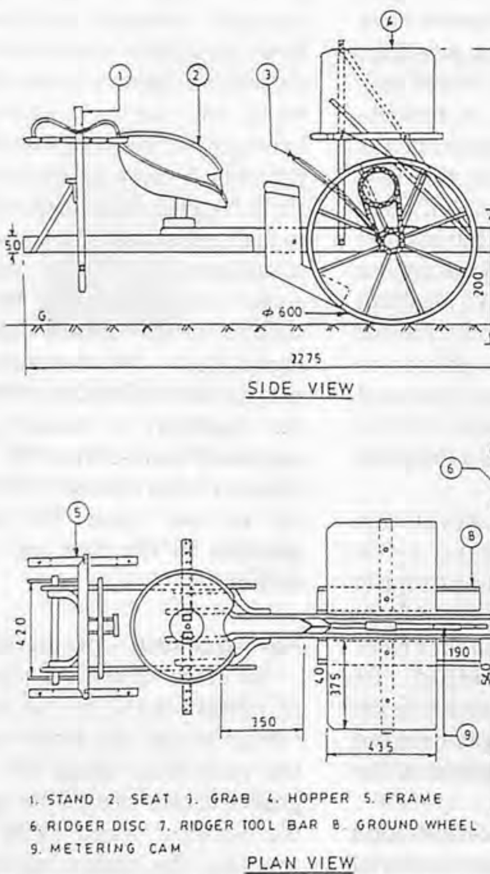

Fig. 1 Semi-automatic cassava planter assembly.

Fig. 2 Tractor mounted imported semi-automatic transplanter modified at national centre for agricultural mechanization, Nigeria, to plant cassava setts in operation.

These components were mounted on the frame of the planter. **(Figs. 1 and 2)**

The planter was a single row machine mounted on the three point linkage of a 70 hp tractor for easy manoeuverability in the field. An operator sitting on the planter **(Fig. 2)** picked a sett from any of the two hoppers and fed it into the rubber-padded open jaws of the revolving grab. The cassava sett was fed with the buds turned upward. The grabs moved in an arc motion actuated by the profile of a stationary cam. The sett was held firmly between the jaws of the grab until it approached its lowest position. When the sett was released in the soil, the gripping pressure of the double rubber pads ceased and the sett was released from the grab. Simultaneously, the sett was covered by soil by the two press wheels moving in oblique position. The angle between the wheels was approximately 40° with the horizontal and the spacing equal to 105 mm. The press wheels were 600 mm in diameter and 93 mm in width. The wheels also rotated the disk on which the grabs were mounted.

Modifications Effected in the Semi-automatic Planter to Plant Cassava Setts

The following design modifications were effected in the imported semi-automatic transplanter to plant cassava setts:

1. Redesign of grabs to hold the cassava setts.
2. Reduction in the number of grabs to maintain recommended plant to plant distance for cassava. The grab number was reduced from 6 to 3.
3. Redesign and modification of driving sprockets for the metering system. This reduced the grab speed for proper feeding of cassava setts.
4. Modification of the planter frame to mount the disk-type ridgers.
5. Selection of ridger disks and bearings.
6. Fabrication of two ridger disk hubs, shafts, standards and ridger frame.
7. Redesigning the three-point linkage system for the planter in such a way that the drive-cum-press wheels rotated smoothly when the ridger disks formed the ridge.
8. The furrow opener was eliminated as it interferred with the placement of the setts and jammed the press wheel.

Methodology

Uniformity of sett-dropping and placement was dependent on the capability of the operator to feed the setts properly as well as selecting proper forward speed of the machine. Initially, the planting accuracy of the modified planter was tested by using two sprockets with a transmission ratio of 6:7. The planter was tested at six different working speeds. Each speed was replicated three times. In order to study the sett-placement, the disk-type ridgers were removed so that the setts being dropped could be seen and counted. The number of setts dropped over 60 m length was recorded. Missing setts were monitored. The working of the planter for proper ridge formation was also tested. Qualitative assessment of the ridges formed was made. Ridge height, wheel slippage and soil hardness were also measured. The results obtained from the preliminary tests were analyzed. The sprockets for the ground wheel/metering were changed to obtain a transmission ratio of 6:12. Further testing was done with the modified machine.

After determining the recommended speeds, the cassava planter was tested to determine the field capacity, field efficiency, fuel consumption and labour requirement per ha.

Table 1. Percent Germination of Cassava Setts at Different Time Intervals After Planting

Dates of Planting	No. of days elapsed after planting	Plant Germination (%) Experimental plots					
		1	2	3	4	5	6
18.5.90	9	Nil	Nil	25	65	Nil	Nil
21.5.90	12	Nil	30	70	70	Nil	10
22.5.90	13	Nil	60	80	80	10	10
24.5.90	15	10	85	85	80	30	20
25.5.90	16	20	90	90	80	40	20
28.5.90	19	55	90	95	90	70	50
29.5.90	20	60	90	95	90	70	50
4.6.90	25	100	100	100	100	80	100

Results and Discussion

Tests results are given in **Tables 2** and **3**. As evident from **Table 2**, the plant row-spacing was 0.96 m. It fell within the

Table 2. Planting Distance and Cassava Placement Accuracy

Planting distance (m)	No. of cassava setts placed correctly	No. of cassava setts not placed correctly	Sett placement accuracy (%)
0.923	52	5	90.38
0.966	52	0	100
0.987	52	1	98.08
0.960	52	2	96.16

Tractor gear: I high, Engine speed: 1 000 rpm, Transmission ratio of sprockets: 6:7.

Table 3. Cassava Sett Planting Accuracy

Test No.	Replications	Tractor gear & engine speed	Working time per 30-m length (s)	Working speed (m/s)	Estimated no. of setts per 60-m length	Actual no. of setts planted per 60-m length	Percent missing	Ridge appearance
I	1	Ist high 1 000 rpm	40	0.750	50-75 (55)	48	12.72	Fair
	2		33	0.909				
	3		32	0.938				
	Avg.			0.891				
II	1	Ist high 1 500 rpm	22	1.364	50-75 (55)	27	50.91	Good
	2		23	1.304				
	3		22.5	1.333				
	Avg.			1.334				
III	1	IInd high 1 000 rpm	22	1.364	50-75 (55)	29	47.27	Very good
	2		22	13.64				
	3		21	1.429				
	Avg.			1.386				
IV	1	IInd high 1 500 rpm	15	2.000	50-75 (55)	18	67.27	Good
	2		17	1.765				
	3		16	1.785				
	Avg.			1.880				
V	1	IIIrd low 1 500 rpm	36	0.833	50-75 (55)	49	10.91	Fair
	2		34	0.882				
	3		35	0.857				
	Avg.			0.857				
VI	1	IIIrd low 2 000 rpm	25	1.154	50-75 (55)	34	38.18	Very good
	2		23	1.304				
	3		26	1.154				
	Avg.			1.204				

Planting distance: 0.80-1.20 m, No. of teeth of driving sprocket: 6, No. of teeth of driven sprocket: 7.

Table 4. Determination of Various Testing Parameters at Different Engine Speeds

Tractor gear /engine speed	Avg. working speed, km/h	Avg. height of ridge (cm)	Avg. working width of ridge (cm)	Avg. planting distance (cm)	Percent missing	Ridge appearance
I high 1 000 rpm	3.60	18.00	99.80	118.33	19.05	Fair
I high 1 500 rpm	5.15	15.60	100.00	103.07	33.33	Good
I high 2 000 rpm	6.77	24.70	99.90	131.33	43.73	Very good
II high 1 000 rpm	4.97	18.30	100.00	111.33	23.69	Good
II high 1 500 rpm	6.70	25.10	98.70	87.00	48.97	Good
III low 1 500 rpm	3.13	23.30	99.00	110.00	12.00	Fair
III low 2 000 rpm	4.39	23.50	100.00	110.10	9.60	Very good
III high 1 000 rpm	6.07	23.60	100.00	105.00	48.65	Fairly good

Table 5. Summary of Field Performance Results of Modified Semi-automatic Cassava Planter

Parameters	Test Number			
	I	II	III	Average
Forward speed (kmph)	4.39	4.39	4.39	
Wheel slippage (%)	2.50	2.50	5.32	
Effective field capacity (ha/h)	0.322	0.389	0.313	
Field efficiency (%)	60.00	61.60	60.55	
Fuel consumption (ℓ/ha)	12.19	12.09	12.13	
Labour requirements (man-h/ha)	3.1	2.57	3.4	
*Cost of planting ridging (₦/ha)	90	90	90	
Ease of operation		Good		
Breakdowns		Nil		

*1 U.S.$ = ₦ (approx.).
Soil Cone Index = 7.93-11.52 kg/cm^2.

recommended plant spacing of 0.80 to 1.20 m. The sett placement accuracy was 98.16%. Further, form **Table 3**, it could be seen that with the best ridge formation, the missing of cassava setts was as high as 38.18% which could be attributed to higher speed of the metering grabs. In order to achieve uniformity of setts placement and dropping, it was, therefore, decided to reduce the speed of the metering system without changing the forward speed of the tractor. It was decided to use a 12-teeth sprocket in place of the 7 teeth to drive the grabs disk. This led to reduction in the metering disk speed of the cassava planter while the tractor forward speed was kept high enough to help in proper ridge formation. With this change, the cassava planter was re-tested in the field.

Results of the planter with 12-teeth driving sprocket are given in **Table 4**. The third low-gear of the tractor with an engine speed of 2 000 rpm was used. For these conditions, the missing setts was reduced to 9.60% which was considered tolerable. The height and width of ridge were 23.5 cm and 100 cm, respectively. These were found to be acceptable. The tractor forward speed was 4.39 km/h. The planting distance measured was within the agronomically recommended value of 80-120 cm. From **Table 5**, it could seen that for the above conditions, the planter field capacity varied between 0.313 and 0390 ha/h with a field efficiency of over 60%. From the same table, it could be seen that the average fuel consumption was 12 ℓ/ha and it required 4 persons to operate the planter.

Conclusions

The research shows that the imported semi-automatic Ellis transplanter which was basically designed for planting of seedlings of vegetables can be modified to use for cassava-sett planting as well. As the planting and ridging were performed simultaneously, it helped to reduce the labour, time and cost requirements for the operations. The imported machines now lying idle in Nigeria could thus be profitably used for cassava planting with minor modifications.

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Performance Evaluation of Yanmar Paddy Transplanter in Pakistan

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Abstract

A performance evaluation of Yanmar ARP-8 paddy transplanter under farmers field conditions with seedling mats grown in plastic tray and on plastic sheet was carried out in Lahore district, during the 1990 and 1991 paddy sowing seasons. The fields were prepared by farmers using conventional tillage practices. Basmati variety seedlings of 20-38 days old were used in this study.

Field results reveal that, on average, the number of missing hills with seedlings grown in plastic trays and plastic sheets were about 5% and was within the allowable limit of transplanter performance standard. The rate of work was 0.32 to 0.40 ha/h under different field conditions. No break downs, were noted during field operations. The machine maneuverability in crossing field bunds and turning was found satisfactory. The control was accessible to the operator during field operation. The cost of mechancial transplanting using nursery seedlings grown in trays was high at (Rs. 1 500/ha) 50% higher than the present manual transplanting costs (Rs. 1 000/ha). The labour requirement for mechanical transplanting (6 man-days/ha) was observed one-third of manual transplanting (17 man-days/ha). the operating cost of the transplanter was minimum (Rs. 850/ha). The transplanting cost includes the expenditure incurred on all operations, performed from nursery raising until the transplanting except land preparation. A 30% increase in yield was recorded in crop transplanted by transplanter compared to manual transplanting.

A laboratory evaluation of the transplanter was also carried out using 20 and 30 days old seedlings of Dr-83 and Basmati 385, paddy varieties grown on plastic sheet. The transplanter was operated at three PTO settings of 80, 70 and 60 to have hill spacing of 14, 16 and 18 cm, respectively. The effect of paddy variety and age of seedlings were observed on number of seedlings per hill at significant level of 99 and 99.9%, respectively. Similarly, the effect of paddy variety was observed on percent of missing hills at 95% level of significance.

On the basis of test results obtained in the field and laboratory, mechanical transplanting using seedlings grown on plastic sheet seems most feasible as it has not only reduced the cost of transplanting (Rs. 850/ha) to the minimum but also have minimized the labour requirements (5 man-days/ha).

Introduction

Rice is an important staple food in Pakistan. It is grown on an area of more than 2 million ha with a total paddy production of about 4.5 million t. The rice is immensely important for the economy of the country, because it is the second largest foreign exchange earning crop. The paddy yields of 9 and 4.6 t/ha have been achieved at farm level for IRRI-6 and Basmati-370, respectively, by adopting full package of production technology as against 3 and 1.8 t/ha of national average[1].

Manual paddy transplanting is one of the laborious and time consuming operations requiring about 250-300 man-h/ha which is roughly 25% of the total labour requirement of rice production[2]. In Pakistan, paddy transplanting is done by manual labour (known as *labas*) on contract basis. At transplanting time, there is an acute labour shortage. This results in increased labour wages and a delayed transplanting operation. The labas also transplant non-uniform and inadequate seedlings population. This is one of the reasons of low paddy yield in Pakistan[3,4] and necessitates the need to introduce mechanized paddy transplanting for timely and better crop stand.

Efforts to Mechanize Transplanting

Pakistan is earning a sizeable foreign exchange from rice export. Efforts were made in the past two decades to increase its production. A brief description of efforts made to mechanize transplanting operation in Pakistan is discussed.

In 1977, a manual paddy transplanter (Chinese version) imported from the Philippines was tested by IRRI-PAK Agri. Machinery Programme at Rice Research Institute (RRI), Kala Shah Kaku. The performance of the transplanter was found satisfactory. However, it was advised to test it extensively[5].

In 1977, the IRRI-Pak Agri. Machinery Programme developed an animal drawn paddy transplanter in collaboration with a private firm. The machine was based on cam operated transplanting concept of the Chinese paddy transplanter. It was tested at RRI, Kala Shah Kaku. The machine could not be operated successfully due to non-uniform walking speed of animals[5].

In 1976, GOP, imported 2 units of 10 rows power operated paddy transplanters from China. These transplanters were evaluated at RRI, Kala Shah Kaku. The performance of the transplanter under local conditions were found unsuitable. The machine was modified by Chinese and Pakistani experts and again tested in 1978 but no success was achieved[5].

In 1976, Korea provided 50 units of six rows engine powered transplanter to Pakistan. The transplanters were tested at RRI Kala Shah Kaku. The severe operational problems were faced and it was concluded that the machine in its original form is not suitable. In 1978 modifications were incorporated to overcome the operational problems. The test results were satisfactory but more time and labour were needed to trim and wash the seedlings. Precise field leveling and presence of uniform water depth in the field were the main hinderances in its adoption[6].

In 1981, FMI tested a tractor rear mounted 7 rows rice transplanter. It transplanted thoroughly separated seedlings in well prepared dry fields with the help of seven labour sitting on the transplanter. The machine was not found suitable due to the small number of hills transplanted[7].

In 1984, a 6-row mat-type self propelled, ridding type paddy transplanter imported from Japan was tested at RRI, Kala Shah Kaku. The machine required seedlings raised in plastic trays. The performance was found excellent and above all farmers appreciated it. Transplanting was found to be more expensive than the conventional method. It was proposed that there was a need to develop a comprehensive plan of research, extension and farmers' training to introduce this technology step by step as the machine was perfect and needed no modification under local conditions[8].

M/s. Guard Agri. Research and Services (GARS), Pvt Ltd., Lahore imported a few units of Yanmar paddy transplanter with mat-type seedlings raising equipment. Despite of M/s GARS, efforts, to introduce this transplanter, no success was achieved[9]. GARS, approached FMI for evaluating/documenting the performance of transplanter and raising of mat type seedlings without plastic trays for economy purpose. Accordingly, the present study was designed to evaluate the transplanter in the field and laboratory with the following specific objectives:

i) To determine the working performance, accuracy and adaptability of Yanmar paddy transplanters.
ii) To compare the economics of mechanical transplanting with the traditional method of transplanting.
iii) To devise a cheap method of raising paddy seedlings and its testing.

Materials and Methods

The Yanmar, ARP-8, paddy transplanter is a self propelled riding type 8-row mat-type paddy transplanter. It is powered by a 4.8 kW, four stroke gasoline engine. It has a fixed row spacing of 30 cm and has provision for adjustments; depth of planting, number of seedlings per hill, plant spacing, floats pressure against soil and planting speed.

The transplanter has a four-bar linkage mechanism for transplanting of seedlings. The transplanting finger separates a chunk of seedlings from seedlings mat and moves downward along its locus. The fork which moves along the finger forcibly separates the seedlings from the finger and inserts them in puddled soil.

Field Evaluation

The transplanter was evaluated using seedlings grown in plastic trays at four locations around Lahore area during 1990 paddy season. In 1991 the transplanter performance was recorded using seedlings grown on plastic sheet at one location. However, at other three locations visual observations were recorded as the seedlings became very old. Three replicates of each test were made.

Raising of Seedlings

The plastic trays were used to raise mat type seedlings. The seeds soaked for 24 h and kept for another 24 h in a moist gunny bag.

The sprouted seeds were sown in plastic trays with the help of a sowing machine. The machine filled required amount of soil in the trays, irrigated it, spread the required quantity of seeds uniformly and covered the seeds with thin layer of soil. The trays were stacked and covered with moist gunny cloth for germination of seeds for 48 h. The seedlings trays were spread in the field for greening.

The NARC has successfully grown the mat-type seedlings on plastic sheet instead of plastic trays. The seedlings preparation method is explained in a manual[10].

Field Preparation

The fields were prepared by farmers themselves using conventional practices. Some farmers plowed their fields using 4-6 passes of cultivator, followed by 2-4 planking in flooded conditions. A few farmers prepared their fields in dry conditions and then irrigated these before transplanting of seedlings.

The recommended practices includes two passes of cultivator followed by one pass of rotavator in flooded conditions[11]. At the time of transplanting the field should be level and hard enough to prevent movement of mud with the movement of transplanter.

Operation and Adjustments

A crew comprising of one operator and three helpers was necessary to run the unit. The operator operates the transplanter. The helpers transport, arrange and load the seedling mats in the compartments. The transplanter was adjusted for hill spacings of 16 and 18 cm, 4-5 seedlings per hill and depth of transplanting up to 4 cm. The adjustments of float pressure and travel speed were made according to field conditions.

Data Recording

Before starting the transplanting operation, data was recorded from three locations at each experimental site for soil hardness at depth of hardpan with cone penetrometer and depth of standing water in the field with a steel rule. Seedling characteristics, like leaf stage, height of a random sample of 20 seedlings and growing density of seedlings in trays at 5 random locations, were recorded. Seedlings of 20 to 38 days old, grown in trays, were used in the experiments during 1990. Soil and seedling characteristics at each experimental site in 1990 are given in **Table 1**. Seedlings of 25 days old, grown on plastic sheet, were used in the experiment during 1991. Soil and seedling characteristics of 1991 field evaluation are given in **Table 2**.

Data was recorded for hill spacing, number of seedlings per hill, transplanted angle, depth of transplanting and defective hills to evaluate the performance of the transplanter, from three randomly selected locations. In order to estimate the cost of transplanting with the transplanter, the data for fuel consumption, working speed and total time taken by the transplanter to complete the work at each site was recorded[12].

Laboratory Evaluation

The transplanter was evaluated in the laboratory using seedlings grown on plastic sheet at FMI, NARC during the 1990 season. The seedlings of 20 and 30 days old of rice varieties Dohkri-83 and Basmati-385 were used. The seedling characteristics and rupture strength of seedling mats were recorded **(Table 3)**.

The transplanter was adjusted for a working speed of 0.75 m/sec. Three plant spacings 14, 16 and 18 cm were used by varying the PTO gear settings of 80, 70 and 60, respectively. Seedling mats were loaded in the trays of the transplanter and the transplanter was moved through a distance of 3.3 m on concrete floor in the laboratory. Observations were made for number of seedlings per hill, missing strokes and distance between consecutive strokes. Each test was replicated four times. Statistical analysis of the results was carried out on computer package M-Stat, using-3 factor factorial completely randomized block design technique.

Table 1. Field and Seedling Characteristics of Experimental Sites, 1990

Experimental site	Soil type	Hardpan depth (cm)	Hardness of hardpan (kpa)	Depth of water (cm)	Age (days)	Leaf (Nos.)	Height (cm)	Growing density (No./cm²)
1.	Loam	20.00	1 490	3.30	20	5.0	23.7	5.75
2.	S.loam	18.25	1 470	2.25	25	5.0	17.5	5.75
3.	S.loam	19.00	1 147	4.30	35	5.5	23.5	5.75
4.	Loam	21.25	970	3.50	38	6.5	18.5	7.25

S - Silt.

Table 2. Field and Seedling Characteristics at GARS, Lahore

Field characteristics	Soil type	Hardpan depth (cm)	Hardness of hardpan (kpa)	Depth of water (cm)
	Silt loam	19.5	1 640	2.2

Seedling characteristics	Age (days)	Leaf (Nos)	Height (cm)	Growing density (No/cm²)	Rupture strength (g)	Mat thickness (cm)
	25	5	14.75	7	875	2.9

Table 3. Characteristics of Seedlings Evaluated in Laboratory

Age of seedlings (Days)	Paddy variety	Leaf stage (No)	Height (cm)	Growing density (No/cm²)	Rupture strength (g)
20	DR-83	5	21.27	7.00	875
	B-385	4	19.25	5.90	1 175
30	DR-83	5	23.25	6.75	1 225
	B-385	5	19.25	5.50	875

Table 5. Percent Distribution of Working Time

Activities	Planting	Turning	Feeding	Adjust-ment
Operator with two helpers for supplying seedlings	55.5	12.5	26.5	5.5
Operator with three helpers for supplying seedlings	73	12	12	3

Table 4. Comparison of Transplanter Performance at Four Sites, 1990

Experi-mental sites	Hill spacing (cm)	Seedling per hill (Nos.)	Planted angle (deg)	Depth of planting (cm)	Missing hills (%)	Working speed (m/s)	Rate of work (ha/h)
1.	14.75	5.00	78.25	4.0	5.50	0.48	0.32
2.	14.75	5.00	76.00	4.0	5.50	0.55	0.36
3.	17.00	4.75	82.50	4.3	6.25	0.72	0.40
4.	14.25	6.00	78.00	4.1	4.00	0.62	0.38

Table 6. Field Performance of Transplanter Using Nursery Grown Seedlings on Plastic Sheet, GARS, Farm

Performance of transplanter	Hill spacing (cm)	Seedlings per hill (No)	Planted angle (degrees)	Depth of planting (cm)	Missing hills (%)
	16	7.5	87	4.1	5.9

Results and Discussions

The transplanter was evaluated in the field using seedlings grown in plastic trays and on plastic sheet during 1990 and 1991 paddy seasons, respectively. Test results are summarized below.

Machine Aspects

The machine is somewhat complex but its adjustments are simple and accessible to the operator during field operations. Machine maneuverability was good along headlands and in crossing field bunds. No major breakdown was encountered. Occasionally, the transplanting fingers and forks were found broken due to poorly prepared and presence of stones in the field. However, the fingers and fork were replaced with locally fabricated steel fingers and aluminum fork.

Seedlings Aspects

Uniformity and density of seedlings in the mat are important regarding working accuracy of the machine. The nursery used for the tests was found satisfactory, meeting all the requirements except age which was older in some cases.

Field Performance with Seedlings Grown in Trays

The working accuracy of the transplanter varied according to field and seedling conditions. The number of seedlings per hill and missing hills were affected primarily by the seedling conditions. The number of missing hills greatly depended on growing density and uniformity of seedlings in the mat. The minimum percentage of missing hills and maximum number of seedlings per hill was recorded at site four **(Table 4)**. Similarly, at site three the percentage of missing hills, was higher than at the other three sites because the seedlings per hill transplanted were comparatively low. The consecutive hills, depth of transplanting and transplanted angle were affected primarily the the field conditions. Although a great variation in the field conditions were observed **(Table 1)** their effect on working accuracy of the transplanter could not be established in this study **(Table 4)**. About 5% missing hills and 5 to 7 seedlings per hill observed were similar to that found by other workers[2,3,13].

The work performance of the machine was measured by the time required to transplant a given area. Working time included the productive (transplanting) and non-productive (time lost in the field) times. The later is comprised of time spent in turning along headlands, supplying seedlings mats, commissioning of machine, repair and adjustment activities. **(Table 5)**, shows the percent of working time spent in these activities during field operation. These observations are in agreement with the report on Japanese mat-type transplanter[13]. Field geometry and puddle conditions greatly affect the productive time. It was noted during the field evaluation that larger and well prepared fields increased the percentage of transplanting time and vice versa. A maximum of 73% productive time was achieved in this study when the fields were large enough and three persons were engaged for arrangements of the seedling mats **(Table 5)**.

Field Performance Using Seedlings Grown on Plastic Sheet

The mat-type seedlings were successfully grown on plastic sheet at four different locations during the 1991 paddy season. The seedlings were of uniform height and uniformly distributed in the mat. The thickness of the mat was not uniform. Small soil clods were present in the mat. The density of seedlings in the mat was very high. The seedlings were weak and small.

It was planned to test the transplanter at all four sites but due to some management problems, the plan did not materialize. The seedlings at three locations became very old (45 days). Therefore, no observations were recorded at three locations. However, visual observations were made. Actual performance of the transplanter was recorded at one place only with 25-day old seedlings at GARS, Farm Raiwind Road, Lahore.

The working accuracy of the transplanter was satisfactory **(Table 6)**. The non-uniform thick-

Table 7. Working Accuracy of Transplanter in Laboratory

Setting of PTO (cm)	Age (days)	Variety	Hill spacing (cm)	Seedlings/hill (Nos.)	Missing hills (%)
18	20	DR-83	18.25	7.75	1.7
		B-385	20.00	6.25	2.9
	30	DR-83	18.25	6.75	5.5
		B-385	18.50	5.75	0.0
16	20	DR-83	16.25	9.00	0.0
		B-385	17.00	6.00	2.9
	30	DR-83	17.75	6.25	0.0
		B-385	16.75	6.00	0.0
14	20	DR-83	13.75	8.25	0.0
		B-385	14.75	5.50	2.9
	30	DR-83	16.00	7.75	0.0
		B-385	15.00	4.75	2.9

B-385 = Basmati-385, DR-83 = Dohkri-83.

Table 8. Statistical Analysis of Laboratory Test Results

Performance Parameters	Variety	Age of seedling	P.T.O. gear setting
Seedlings per hill (nos)	**	***	N.S.
Missing hills (%)	*	N.S.	N.S.
Hill spacing (cm)	N.S.	N.S.	***

* Significant at 95% level of significance.
** Significant at 99% level of significance.
*** Significant at 99.9% level of significance.
N.S: Non-significant.

ness of mat and presence of small clods in the mat resulted in high percentage of missing hills as they clogged the finger and fork of the transplanter. The number of seedlings per hill were high due to high seedling density. The small seedlings also increased the number of buried hills. The visual observations made with the 45-day old seedlings at three other sites show that non uniform thickness of the mat, cluster of roots and presence of clods in the mat greatly reduced the performance and accuracy of the transplanter. After transplanting the mortality rate was high.

The preceding problems could be rectified by following the given instruction. The uniform thickness of the mat can be controlled by allowing the bed to dry and regain strength for sufficient time according to soil type, before spreading the plastic sheet on the bed. Clod-free mud should be placed on sheet. For healthier seedlings, some fertilizer should be added in the mud. To optimize the seedlings density in the mat, a 15 to 20 kg/ha seed rate should be used.

On the basis of the test results it can be stated that seedlings grown on plastic sheet can replace the seedlings grown in trays, if efforts are made to maintain proper thickness of the mat, density and height of seedlings.

Laboratory Evaluation

The laboratory evaluation of the transplanter was also carried out using 20- and 30-day old seedlings of DR-83 and Basmati 385 rice varieties grown on plastic sheet during the 1889 paddy season. The characteristics of seedlings used in the study are given in **Table 3**. Whereas the performance results and statistical analysis is given in **Tables 7** and **8**. Comparing the working accuracy of the transplanter at different P.T.O settings with two rice varieties of two age groups, the P.T.O gear setting had no effect on the percentage of missing hills and number of seedlings per hill but it affected the hill spacing only **(Table 7)**. However, statistical analysis of the results **(Table 8)** shows that there is a significant effect of P.T.O setting on hill spacing which is at 99.9% significance level. Similarly, the number of seedlings per hill were also affected significantly by variety and age of seedlings at 99 and 99.9% level, respectively. The analysis further indicated significant effect of paddy varieties on percent of missing hills at 95% level.

It was noted during the laboratory evaluation that missing hill percentage and seedlings per hill were dependent on the distribution and uniformity of seedlings in the seedling mats. If the seedlings distribution in the mat was uneven then the missing hills percentage increases and vice versa. It was also noted that the transplanting finger did drop small portions of mat taken by them from the seedlings mat at their downward position, irrespective whether there were seedlings in it or not.

Economics of Mechanical Transplanting

The economics of using any machine usually depends on machine purchase price, labour charges and working capacity of the machine. Among these factors, machine purchase price varied and is an unpredictable factor, especially when it is imported. During the 1990 paddy season the purchase price of the transplanter was Rs. 225 000. On the basis of this price the economics of the transplanter was calculated **(Table 9)**.

In the 1991 paddy season, the purchase price of the transplanter increased from Rs. 225 000 to Rs. 375 000. Hence, once, again all the calculations were made **(Table 10)**. These two tables highlights the significant effect of price on operating cost. **Table 9** shows the initial investment, labour requirement, operating cost and additional benefits of using mechanical transplanter with seedling mats grown in trays and on plastic sheet. The cost of manual transplanting is also given in the same table for comparison. It indicates that 5 man-days/ha were needed for mechanical transplanting using seedling mats, grown on plastic sheets against 17 man-days/ha for manual transplanting. Initial investment is high (Rs. 600 000) when the transplanting is done with the seedling mats grown in plastic trays. No initial investment is needed for manual transplanting. Similarly, the operating cost/ha was Rs. 1 300 for the mechanical transplanting with seedling mats grown in plastic tray

Table 9. Economics of Mechanical vs Conventional Transplanting, 1990

Description	Initial Investment (Rs.)	Labour Investment (man-day/ha)	Operating Cost (Rs/ha)	Additional Benefit (Rs/ha)
Mechanical transplanting nursery grown in trays	600 000	6.0	1 300.00	3 500
Mechanical transplanting (nursery grown on plastic sheet)	250 000	5.0	750.00	
Manual transplanting		17.0	950.00	

Assumptions:

Cost of paddy transplanter	Rs. 225 000
Cost of trays	Rs. 335 000
Cost of power operated soil crusher sieve	Rs. 15 000
Cost of sowing machinery (nursery)	Rs. 25 000
Cost of plastic sheet	Rs. 25 000
Annual Use	100 hectares
Repair/maintenance cost	3% of purchase price/annum
Labour wages	Rs. 50/day/8hrs
Paddy price	Rs. 110/40 kg

Table 10. Operating Cost of Mechanical vs Conventional Transplanting, 1991

Description	Labour requirement (man-day/ha)	Operating cost (Rs/ha) 50 ha	75 ha	100 ha	Additional benefit (Rs/ha)
Mechanical transplanting nursery grown in trays	6	1 950	1 650	1 500	3 500
Mechanical transplanting nursery grown on plastic sheet	5	1 250	1 000	850	3 500
Manual transplanting	17	1 000	1 000	1 000	—

Assumptions: Cost of paddy transplanter Rs. 375 000. Increase in yield is same of 1990.

Table 11. Initial Investment of Three Transplanting Systems, 1991

Area (ha)	Initial investment (Rs.) Mechanical transplanting trays	Mechanical transplanting with plastic sheet	Manual transplanting
50	585 000	400 000	NIL
75	670 000	410 000	NIL
100	750 000	420 000	NIL

against Rs. 950/ha for manual transplanting. It is also evident that mechancial transplanting with seedling mats grown on plastic sheet is the economical method as it has not only reduced the operating cost to the minimum but also have minimum labour requirement. In 1990, 30% increase in yield was recorded in crop transplanted by transplanter as compared to manual transplanting. Therefore, an additional benefit of Rs. 3 500/ha was realized by using the mechanical transplanter.

In the second phase of testing, the transplanter was evaluated in the field using seedlings grown on plastic sheet during the 1991 paddy season. The increased price of the Yanmar transplanter necessitated a new calculation for the economics of using the transplanter. The economics of mechancial transplanting with annual use of the transplanter on 50, 75 and 100 ha, was made in order to have an idea of break-even point of the machine. **Table 10**, shows that the mechanical transplanting with seedlings grown in trays is uneconomical for all three areas. Mechanical transplanting with seedlings grown on plastic sheet was the cheapest, when the seasonal use of transplanter is 100 ha. Whereas, it is similar to the manual transplanting when the seasonal use of transplanter was 75 ha. So, it can be concluded that the mechancial transplanter with seedlings grown on plastic sheet is comparable in cost to manual transplanting apart from other benefits of timeliness, comforts and higher crop return. **Table 11**, shows the initial investment of the three system of paddy transplanting.

Conclusions and Recommendations

On the basis of the performance evaluation of the Yanmar ARP-8 paddy transplanter under farmers field conditions with seedling mats grown in plastic tray and on plastic sheet and laboratory evaluation with seedling mats grown on plastic sheet only, the following conclusions are drawn.

a) There was no major breakdown observed during the field operation. The machine adjustments are easy and can be learned by the operator by following the manual instruction.

b) On the average, the number of missing hills with seedlings grown in trays and on plastic sheets were about 5% and was within the allowable limit of transplanter performance standard.

c) Mechanical transplanting with mat type seedling grown on plastic sheet was found most feasible as it has not only reduced the operating cost (Rs. 850/ha) to the minimum but also have minimum labor requirement (5 man-days/ha).

d) The effects of paddy vareity and age of seedlings on number of seedlings per hill was statistically significant at significance level of 99 and 99.9%, respectively. Similarly, the effect of paddy variety on percent of missing hills was also significant at 95% level.

e) As the machine is somewhat complex, farmers will require a thorough practical training to obtain a good working knowledge of its operation.

f) The initial investment is rather too high for the majority of the farmers to afford, especially at the initial stages, as the benefits and effectiveness of the technology have not yet been demonstrated to them. So it is recommended the feasibility of manufacturing the transplanter in the country may be studied. Local manufacturing will ensure cheap availability of the transplanter for the farmers.

(Continued on page 40)

Design and Development of a Small Container for Controlled Atmosphere Storage

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Abstract

A low-cost controlled atmosphere storage system was designed and constructed based on the principle of steady state diffusion. The system was developed from a 100 × 75 × 60 cm PVC container. By using Fick's law of diffusion, it was provided with two diffusion channels, one for oxygen equilibrium and the other for carbon dioxide. The relative humidity was controlled by means of a saturated solution contained in a channel especially designed for that purpose as well as to provide a good airtight operation.

The main objective was to establish a dynamic equilibrium between the rate of respiration of the produce and the rate of diffusion of gases in and out of the system, thus permitting the control of these gases throughout the storage period.

Lettuce was used for testing the CA container under a pre-established atmosphere of 3.5% O_2 and 0.5% CO_2. Results showed that the container can be used to provide controlled atmospheres low-cost conditions for perishable products.

Introduction

Losses in quantity and quality occur in fruits and horticultural products between harvest and consumption. Kader (1985) estimated the magnitude of postharvest losses in fresh fruits and vegetables to be between 5 and 25% in developed countries, and between 20 and 50% in developing countries. The losses are highly dependent on the availability of proper storage facilities.

The storage period for fruits and vegetables varies widely. Some, e.g., apricots, green peas and tomatoes, may be stored for a few days to two weeks, while others may be stored for longer periods, up to 8 months for apples and potatoes. (Kader, 1985).

Even though biological or physiological changes in fresh produce cannot be completely stopped by certain techniques, it is possible to slow them down within certain limits.

One of these technique is known as Controlled Atmosphere (CA), which means the precise control of atmospheric gases in a storage environment where the concentration of carbon dioxide is high and that of oxygen low. The effect is to reduce the rate of respiration of the crop, with the result that it may be stored for a longer period at a higher temperature than the usual time.

Controlled Atmosphere systems can be used during transport or temporary or long-term storage of perishable commodities destined for fresh market or processing. Occasionally, other gases, such as carbon monoxide are added in low concentrations to keep cut surfaces from darkening, but this practice is not considered to be part of CA storage (Kader, 1985).

The effects of CA depend on the nature of the product stored, environmental variables, building and duration of storage. However, the product to be stored must be first-class quality. Controlled atmosphere storage can only maintain quality: not to improve initially inferior products. This is very important because CA stores are expensive to build and equip, and may not be an economic proposition in some cases (Zahradnik and Southwick, 1958).

Among the environmental factors investigated by postharvest researchers, temperature, relative humidity, carbon dioxide and oxygen seem to be the most important variables related to deterioration of perishable in store (Lau, 1983; Lougheed, 1987; Smith and Reyes, 1988). Previous research has been carried out to develop low cost CA stores, but not many of them have also considered the control of relative humidity (Ayenew, 1990).

The development of CA storage conditions easy to construct with minimum cost is a very good alternative and can be applied in developing countries. For those reasons, the objectives of this project were:

1. To design a low-cost controlled atmosphere storage system, which included the control of relative humidity; and
2. To perform a preliminary test for the short-term storage.

Materials and Methods

Definition of Variables

A 100 × 75 × 60 cm low-cost controlled atmosphere container was designed and constructed. The size was used for experimental purposes to permit the control of temperature, carbon dioxide and relative humidity.

A common and applicable gas exchange equation is a modified form of the Fick's law equation,

$$E = -D * (Ci - Co) * A/X$$

where E is the mass transfer of the gas, Ci and Co are the concentrations of the gas within and external to the commodity respectively, A is the portion of the commodity's surface and are perforated by air-filled spaces, and X the thickness of the barrier limiting gas exchange.

The diffusion coefficient D is related to air pressure and the absolute temperature as follows:

$$D = Do * (T/To)^m * (P/Po)$$

with Do as the diffusivity of the gas at 273°K and 760 mm Hg, and m a constant between 1.75 and 2 depending upon the nature of the gas mixture.

Assuming m = 2 and that there is no difference between the pressure P in the commodity and the atmospheric pressure Po, then, the value of D may be calculated such that:

$$D = Do * (T/To)^2$$

The basic design variables to achieve CA conditions were: the respiration rate of the product, the desired levels of carbon dioxide, oxygen and relative humidity, the diffusion coefficients of the gases, the mass of the product, and the temperature.

Respiration Rate

This is one of the most important factors to be considered in the design of a CA container. In the present study, respiration rates of the produce were assessed in the laboratory at 10°C and two atmospheric conditions: in normal air, and at 3.5% O_2 & 0.5% CO_2.

Cos lettuces were used in this experiment, which were placed in a sealed 30 × 30 × 15 cm plastic chamber (**Fig. 1**). The atmosphere of the closed system circulated through an infrared CO_2 analyzer and an oxygen meter. To avoid side effects on respiration rate, the duration of the test was limited to a period of 4 hours. An increase in CO_2 from 0.03 to 0.5% was achieved by extracting around 2 litres of air from the container and injecting the quantity of pure carbon dioxide.

Maintaining CA Conditions

In order to maintain oxygen and carbondioxide as desired, it was necessary to design the diffusion channel for these gases. Carbon dioxide removal was achieved by means of a bottle containing 500 grams of soda lime, which was connected to the container's atmosphere through a tube having the area to the length ratio (A/X) equal to 1.416 cm. The O_2 consumed by respiration of the crop was replaced through a diffusion path of 0.223 cm diameter and 0.25 cm length. Cos lettuces (3 kg) were placed inside the PVC tank supported by a plastic tray (**Fig. 2**).

In order to keep the desired CA conditions, the tank was sealed by means of a water channel, which was used both to seal the container and to control relative humidity. A saturated solution of potassium nitrate (11 500 cm^3) was placed in

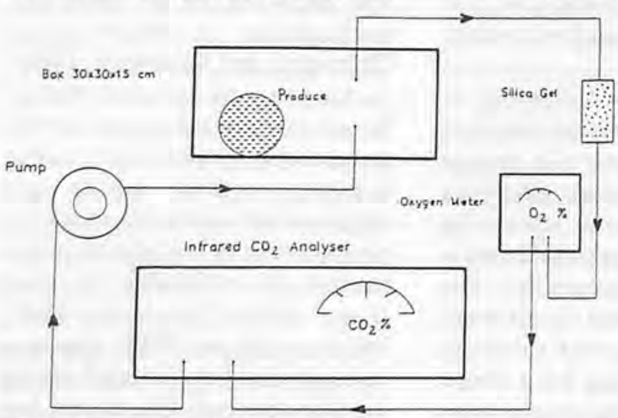

Fig. 1 Measurement of O_2 and CO_2 concentrations in a closed system.

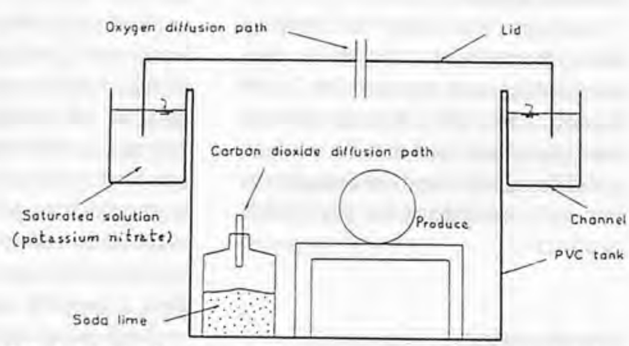

Fig. 2 Schematic diagram of the prototype CA storage container.

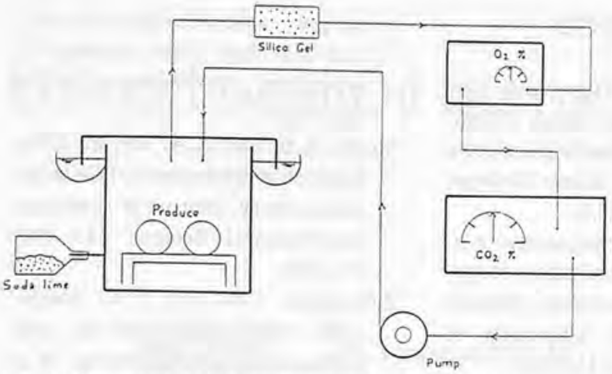

Fig. 3 Monitoring of CA environment in the container.

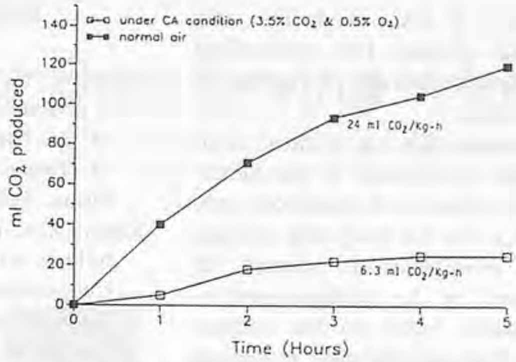

Fig. 4 Respiration rate of Cos lettuce in normal air and under CA conditions.

the channel to provide a relative humidity at 95% level in the container (**Fig. 3**).

The CO_2 concentration was monitored with an infrared CO_2 analyzer, whereas the O_2 was measured by using a Taylor Servomex type OA 250 oxygen analyzer. Relative humidity was measured with a Michell Series 3000 dew-point thermometer.

Table 1. Concentrations of CO_2 and O_2 within a Storage Container at 10°C. Nominal Atmospheric Composition (3.5% O_2 and 0.5% CO_2)

Days		Time of Measurement			
		0800	1200	1600	2000
1	$\%CO_2$	0.50	0.50	0.48	0.45
	$\%O_2$	3.50	3.53	3.55	3.62
2	$\%CO_2$	0.50	0.50	0.52	0.60
	$\%O_2$	3.40	3.45	3.52	3.65
3	$\%CO_2$	0.58	0.67	0.60	0.61
	$\%O_2$	3.65	3.64	3.65	3.55
4	$\%CO_2$	0.60	0.63	0.62	0.65
	$\%O_2$	3.52	3.63	3.75	3.52
5	$\%CO_2$	0.55	0.65	0.65	0.65
	$\%O_2$	3.72	3.52	3.55	3.45

Results and Discussion

Respiration measurements of the Cos lettuce studied in this experiment are presented in **Fig. 4**. It was found that Cos lettuce respires much more slowly under CA and high humidity conditions at 3.5% O_2 and 0.5% CO_2 than in normal air. As shown, the respiration rate of the commodity was slowed by about 4 times under CA conditions.

In a previous experiment, Ayenew (1990) working with Iceberg lettuce found a similar trend. The respiration rate of the produce under normal air was 14.95 ml CO_2/kg-h, whereas under CA conditions at 3% O_2 and 1% CO_2 it was 1.34 ml CO_2/kg-h (about 10 times faster in normal air).

Even though the atmospheric conditions were different, the higher respiration rate of the Cos lettuce can be explained by a higher surface area of leaves as compared to Iceberg lettuce. According to Fick's law of diffusion, the higher the surface area of the produce the higher the mass transfer (Kader, 1985).

Observations of the conditions inside the CA container are shown in **Table 1**. Data from this experiment suggest that the CA tank could maintain the gas concentrations as desired. Atmospheric analysis showed that the oxygen concentration fluctuated between 3.4% and 3.75% during the storage period. This suggests that the gas exchange process was in dynamic equilibrium, with the same amount of oxygen diffusing into the system as compared to the amount of oxygen utilized by the lettuce.

Regarding carbon dioxide, the scrubbing of this gas proved to be satisfactory in maintaining the concentration as desired. It rose 30% from the target value of 0.5% and reaching 0.65% at the end of the storage period.

The extraction of samples from the storage chamber for oxygen analysis was avoided in this experiment. Earlier, Ayenew (1990) found that the removal of samples would adversely influence the gas equilibrium in the storage environment. By using an oxygen analyzer on this occasion it was not necessary to remove samples from the CA container, thus avoiding such problems. Carbon dioxide as well as oxygen concentration was measured by the constant circulation of air in the system. It proved the system to be satisfactory since no atmosphere was lost during the analyses.

Relative humidity fluctuated in the range of 93% to 97%; it was not necessary to replace water in the channel because of the minimal water loss during the storage period.

Conclusions and Recommendations

From the results, it can be concluded that it is possible to develop a less expensive and simple system for controlled atmosphere storage of vegetables and fruits.

Because this was a short term storage experiment, it was necessary to achieve CA conditions very quickly, but for long term storage such modifications should be achieved by the produce itself.

Further work on the subject with different building materials and room sizes during long term observations is necessary. Also, it could be possible to achieve through the use of different concentrations of oxygen and carbon dioxide in the storage environment.

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(Continued from page 36)

Performance Evaluation of Yanmar Paddy Transplanter in Pakistan

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Using Local Oil Burner for Corn Drying in Iraq

by

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Abstract

Autumn corn is usually harvested in Iraq during the winter when temperature is low and relative humidity is high, so drying is necessary for shelling ears and for safe storage. Heated air is usually used for drying. The local kerosine burner was used in this investigation for heating the air.

It is found that in spite of the low efficiency of the local burner, it is more prefered than the imported one because of its low cost in that the cost of kerosine in Iraq is very low.

Introduction

Autumn corn is usually harvested during the period between mid-December and the end of January when the average temperature is less than 16°C and the average relative humidity is more than 75%[5], hence using natural air in drying is not efficient[3&4].

The harvested ear corn has 30% moisture content or more, which is regarded too high for storage or shelling. The maximum moisture content for shelling is 25%, otherwise the grains are partially shelled and tend to doughing[1]. Besides that the grain without drying will be moldy, hence it is necessary to reduce moisture content for safe shelling and storage.

The farmer who risks using combines without the help of a dryer is at a disadvantage for he must always wait for the grain to dry[2]. Ear corn can be dried if it is put under shelter and turned occasionally, but this method is done during a period of two weeks and it exposes the seeds to birds' attack.

In Iraq, local kerosine burners are used in commercial bakery or for boiling the water of the baths of old houses. The bath floor temperature becomes very high and the bath room becomes very hot as in Turkish bath.

The aim of this paper is to use the local oil burner in drying corn and to find its efficiency in removing excess moisture content from ear corn.

The experiment was conducted during December 1989 and January 1990.

Materials and Methods

A dryer was made as shown in **Fig. 1**. The details which are not shown in the figure are:

1. The capacity of the dryer was 650 kg of ear corn which is 40 cm deep over the hot air duct — the same distance between the hot air duct and the dryer side.[4]

The duct contains 800 holes of 2.5 cm in diameter, or the total area of the holes was 3 925 cm^2 representing about 30% of the total area of the duct.[6]

2. The air blower is of trade mark (Back Word), centrifugal type, and three phase electric power. The specifications of the blower were tested and found to be 2850 rpm, 2.2 kW (2.95 hp), discharge of 76.5 m^3/min, the static pressure was zero with door fully opened, 0.9 cm water with door half-closed, and 6.4 cm water

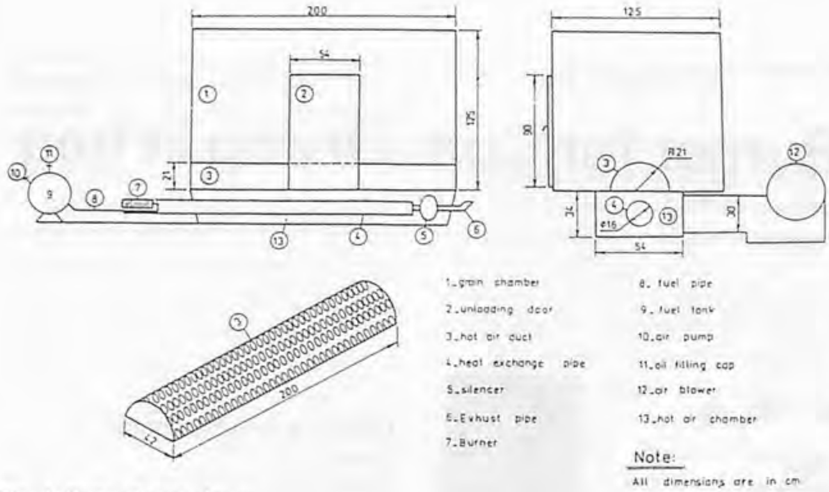

Fig. 1 Parts of corn dryer.

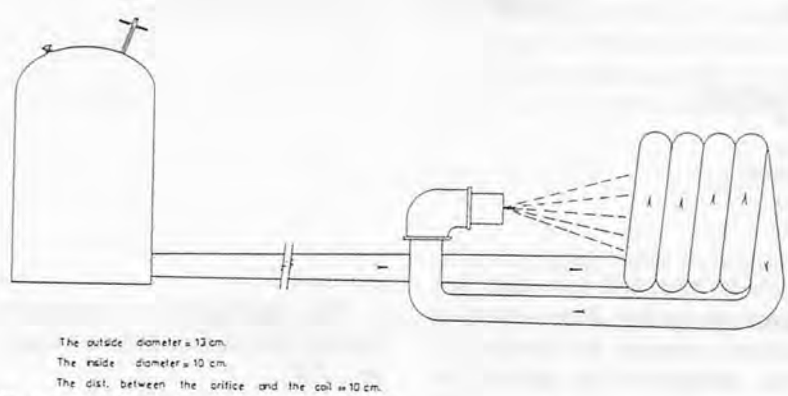

Fig. 2 Local burner used in the experiment.

with door fully closed.

3. The burner as shown in **Fig. 2** is locally made of coiled water pipe of 12.5 mm in diameter. The oil flows through the pipe under the compressed air on the oil by hand air pump.

Some preparations are needed to ignite the fuel. Usually a piece of tissue paper or fiber glass dampened with kerosine is put inside the coil and ignited. This operation converts the liquid fuel to vapor which flows through the burner orifice and the jet of fire goes inside heat exchange pipe. Igniting the burner needs about 5 minutes.

Two burners were used. Each burner was used to dry five samples of ear corn of 650 kg each. Each sample was exposed to heated air for 10 h during the day time.

Results and Discussion

Some results were constant while others were variable. The constant results were: the average weight of each sample of 650 kg, and the average fuel consumption of 12 kg/day for each burner.

The results are tabulated in **Table 1.**

Table 1. Results of the Experiment

Sample No.	Average air temp. before heating (C°)	Average air temp. after heating (C°)	Average air relative humidity (%)	Moisture content before drying (%)	Moisture content after drying (%)
1.	12.27	19.72	71.1	28.5	24
2.	11.90	18.90	70.2	29.0	25
3.	15.03	22.03	52.3	30.5	24
4.	15.55	21.55	48.4	30.0	23
5.	14.01	21.01	55.5	30.5	24

The caloric value of kerosine is 10 553 kcal/kg. The average fuel consumption per day was 12 kg., hence 10 553 × 12 = 126 636 kcal input heat value

From **Table 1,** the average decrease of moisture content was 5.7%. The weight of the sample was 650 kg., hence 0.057 × 650 = 37 kg. of water removed per sample.

Each kg. of removed water needs 585 kcal[3], hence 37 × 585 = 21 645 kcal outlet heat value.

$$\eta = \frac{21\,645}{126\,636} \times 100 = 17.1\%$$

This efficiency is regarded too low compared with the efficiency of good burners which reaches 28%[4], but it could be acceptable in Iraq because the price of the burner is 150 Iraqi dinars which is less than the cost of its freight if it was imported, and the cost of kerosene in Iraq is very cheap which is less than one U.S. cent per liter, hence the low value of efficiency can be justified.

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Moisture Exchange Between Wet and Dry Wheat Kernels as Affected by Temperature and Disturbance

by
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Summary

A variety of bread wheat (Saberbeg) was used in this study. Sample of wet (29.2% WB) and dry kernels (8.6% WB) were blended. These samples were stored at various temperatures (2, 12, 20 and 28.5°C), and some of these samples were disturbed and the rest were left undisturbed. The first - order Kinetic equation, MR = exp − Kt was used to determine the time (t) required for equilibrium moisture content (EMC), for both dry and wet portions. The interchange of moisture in the blend was very rapid in the first two days, then it slowed down afterwards. Increasing the temperature and introducing the shaking effect decreased the time required to approach the EMC.

Introduction

In general, mixing grains with different properties is important to ensure best technical and economical results for food processing equipment used and food products. So blending these grains is not only a mechanical procedure, but it is also considered to elaborate between the mix constituents of which desired specific properties are obtained. Moisture content (MC) is believed to be the critical factor in introducing such properties. Moisture migration among grains having different MC is important in grain transportation, grain storage, or grain processing operations. Moisture exchange among grains has been the subject of many studies and an extensive review of the subject was presented by Brooker et al., (1974). However, little is known about the nature and the extent of the process of moisture interchange involved.

MC of the grain that is in euqilibrium with the surrounding air is termed as (EMC). Blending wheat grains with different MC was experienced by Hart (1964) who stated that higher temperature decreased the time length for mixed grains to reach EMC. Later, Hart (1967) showed that mixing high and low moistured corn portions gave a different MC between the portions of the blend. The difference was about 3%. This was also noticed by Hubbard et al., (1957) who reported a little difference in EMC between grains in the blends.

The objectives of this study were to find out a mathematical relationship between moisture movement, temperature, and disturbance effects in the wheat blend. It also aims to design a natural method of exchanging moisture between wet and dry wheat kernels without the use of mechancial or electrical methods.

Materials and Methods

A bread wheat variety (Saberbeg) brought from The Authorizing Grain station in Mosul was used for all parameters studied. The wheat grains were dry cleaned and graded by laboratory cleaning and grading machine type Westrup LALS No. 77015/72145616 of Swedish source. Medium sized grains were chosen for this study to discard any variable which would affect the parameters studied. The MC of the grain was determined by using an electronic device. One part of the grain was tempered to 29.2% MC (WB) using AACC method. The wet grains were damped in solution of food dye (0.5 g food dye/litre water) for 10 min. The grains were brought out of the solution and dried off using filter paper. The other part of wheat was over-dried to 8.6% MC (WB) by air-oven (100°C).

The following equation was used to enable the dry-wet wheat blend to reach the theoretical average of 14% MC (WB).

$$0.14\,(X + y) = 0.292y + 0.086X \quad ...(1)$$

where:

X = weight of dry grains at 8.6% MC (WB),

y = weight of wet grains at 29.2% MC (WB).

let X = 250 g and by using the above equation gives y = 704 g.

Fifteen blend samples of wet and dry grains as equated above were prepared and put in a polythene bags and thoroughly mixed by shaking. Six of these samples were stored at 2°C and the other samples were stored at 12, 20, and 28.5°C. Three of samples stored at 2°C were frequently shaken throughout the storage period and the rest were left without disturbance. Similarly, the other samples stored at 12, 20, and 28.5°C were left undisturbed.

The determinations of MC of wet, dry- and mix of blend was taken at 24 h intervals with three replications.

An ENER GRAPHICS computer programm was used to draw the curves.

Results and Discussion

The initial MC of each portion in the blend and the blend itself was measured at the begining of the test (Zero "0" time). All data represented here is the mean of three replications.

Table 1 contains the moisture changes of disturbed and undisturbed wheat blend stored at 2°C. In general, the results shows that moisture interchange between wet and dry kernels is very rapid in the first two days, then the rate of moisture migration slows down. Although the six samples were stored under the same temperature (2°C), the disturbed sample is shown to reach the EMC faster than the undisturbed sample.

It will be shown in **Figs. 1** and **2** that the disturbed samples

Table 1. Moisture Changes in Disturbed and Undisturbed Wheat Blends When Stored at 2°C

Time	Disturbed			Undisturbed		
(h)	Wet	Mix	Dry	Wet	Mix	Dry
0	29.2	14.0	8.6	29.2	14.0	8.6
24	20.0	14.3	12.3	20.5	14.2	12.0
48	17.8	13.5	12.6	18.7	13.5	12.4
72	17.2	13.7	12.9	18.0	13.5	12.9
96	17.0	13.7	13.0	17.6	13.5	12.9
120	16.7	13.7	13.2	17.4	13.5	13.1
144	16.7	13.7	13.4	17.2	13.6	13.3
168	16.6	13.7	13.4	17.0	13.7	13.4
192	16.5	13.7	13.6	16.7	13.6	13.4
216	16.5	13.7	13.5	16.8	13.5	13.2

Table 2. Moisture Changes of Undisturbed Wheat Blend Stored at Different Temperatures

Time	MC% at 12°C			MC% at 20°C			MC% at 28.5°C		
(h)	Wet	Mix	Dry	Wet	Mix	Dry	Wet	Mix	Dry
0	29.2	14.0	8.6	29.2	14.0	8.6	29.2	14.0	8.6
24	17.8	14.2	12.8	17.1	14.1	13.2	16.9	14.2	13.5
48	16.2	14.1	13.5	15.5	14.2	13.7	15.2	14.2	14.0
72	15.8	14.0	13.9	15.0	14.4	14.0	15.0	14.3	14.1
96	15.4	14.0	14.0	15.0	14.4	14.1	14.6	14.4	14.1
120	15.3	14.0	14.1	14.8	14.4	14.0	14.6	14.5	14.3
144	15.0	14.2	14.0	14.8	14.3	14.2	14.5	14.4	14.2
168	15.0	14.0	14.0	14.5	14.5	14.1	14.5	14.5	14.3
192	14.8	14.0	14.1	14.3	14.3	14.2	14.6	14.6	14.4
216	14.9	14.1	14.0	14.3	14.2	14.2	14.4	14.2	14.3

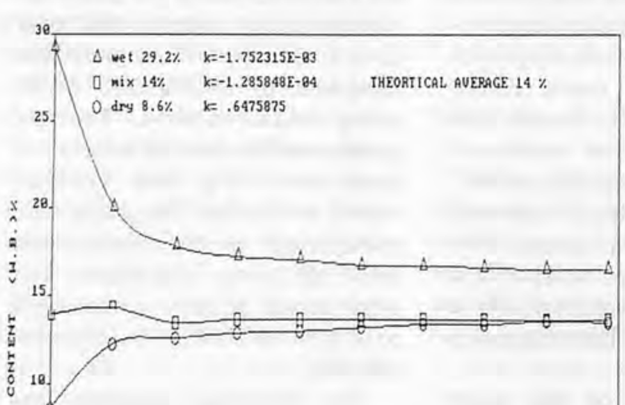

Fig. 1 Moisture content versus time for disturbed wheat at 2°C.

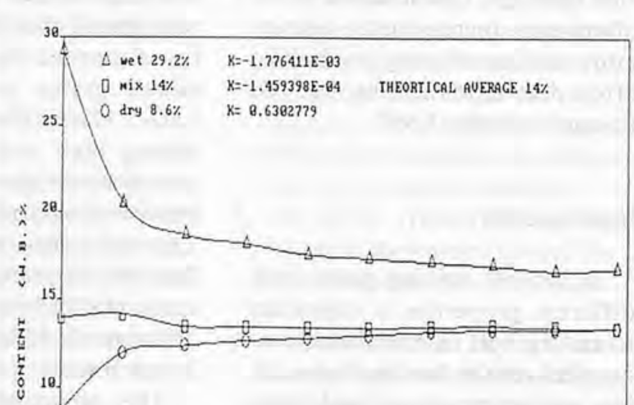

Fig. 2 Moisture content versus time for undisturbed wheat at 2°C.

reached the EMC after 72 h, while the undisturbed sample reached it after 120 h. Accordingly, the mixing of wheat blend has faster effect on reaching the EMC at the same temperature. However, at EMC for both disturbed and undisturbed blends, there is a different MC between wet and dry portions of the blend. The difference is 4.3%, a difference of 3% was reported by Hart (1967) who worked on corn blend.

When other storage temperatures (12, 20, and 28.5°C) were used with wheat blends, moisture migration was shown to be at a higher rate than samples stored at 2°C, either disturbed or undisturbed samples **(Tables 1** and **2)**. On the other hand, the time required for EMC decreased as the temperature increased. In addition, the difference in MC at equilibrium between wet and dry portions in the blend was progressively reduced as the temperature was increased.

The moisture ratio (MR) and time (t) relationship can follow a first-order Kentic equation, as:

a) for the desorbing wheat;

$$MR = \frac{M - Me}{Mo - Me} = \exp - Kt$$

b) for the adsorbing wheat;

$$MR = \frac{Me - M}{Me - Mo} = \exp - Kt$$

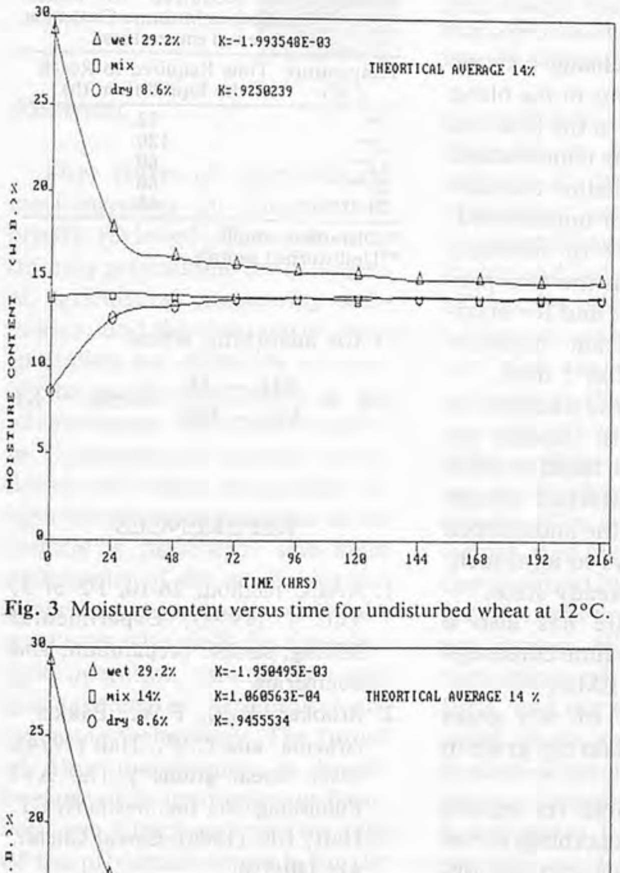

Fig. 3 Moisture content versus time for undisturbed wheat at 12°C.

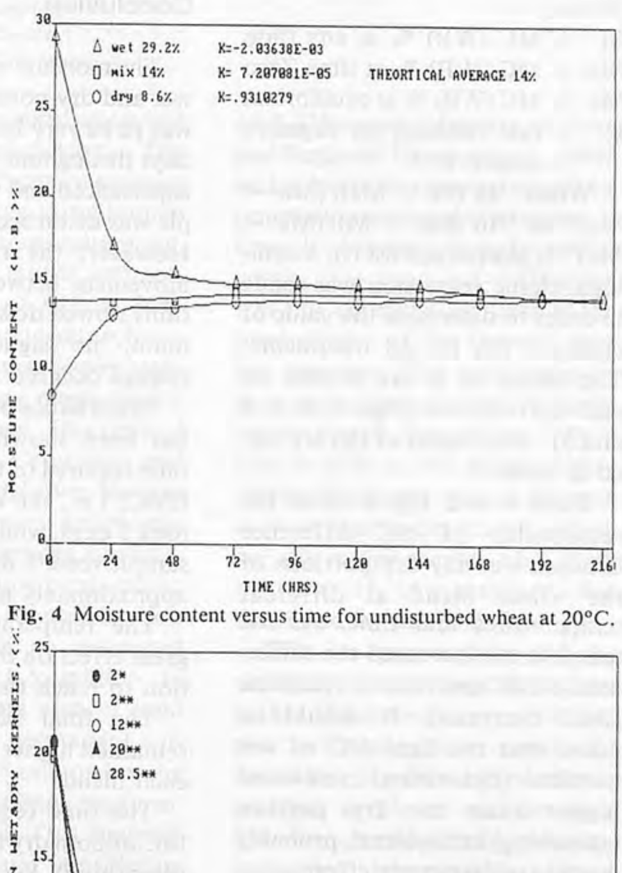

Fig. 4 Moisture content versus time for undisturbed wheat at 20°C.

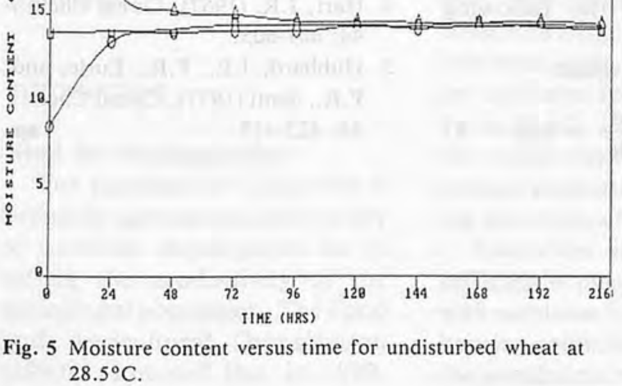

Fig. 5 Moisture content versus time for undisturbed wheat at 28.5°C.

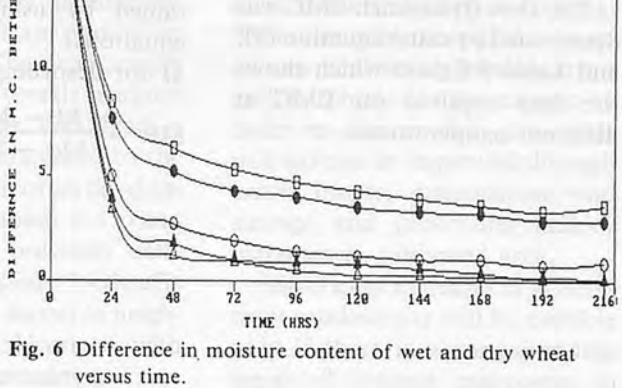

Fig. 6 Difference in moisture content of wet and dry wheat versus time.

Table 3. Values of Costant K

Temp. C		Disturbed wheat	Undisturbed wheat
2	wet	−1.75 −03	−1.78 −03
	mix	−1.29 −04	−1.46 −04
	dry	0.65	−0.63
12	wet		−1.99 −03
	mix		
	dry		0.93
20	wet		−2.04 −03
	mix		7.21 −05
	dry		0.93
28.5	wet		−1.95 −03
	mix		1.06 −04
	dry		0.95

Where:

M = MC (WB) % at any time

Mo = MC (WB) % at time Zero

Me = MC (WB) % at equilibrium

K = rate constant (or negative slope), h^{-1}.

When "In (M − Me)/(Mo − Mc)" or "In (Me − M)/(Me − Mo)" is plotted against (t), a semilogarithmic regression was made in order to determine the value of constant (K) for all treatments. The values of K are written on each curve drawn (**Figs. 1, 2, 3, 4** and **5**). Also values of (K) are listed in **Table 3**.

Table 4 and **Fig. 6** show the relationship of MC difference between wet any dry portions of the wheat blend at different temperatures and time. As the temperature increased the difference in MC and time to reach the EMC decreased. It should be noted that the final MC of wet portion (desorbing) remained higher than the dry portion (adsorbing) in the blend, probably due to the hysteresis effects.

The time (t) to reach EMC was determined by using equation (3), and **Table 5** figures which shows the time required for EMC at different temperatures.

Table 4. Moisture Content Difference between Dry and Wet Portions in Wheat Blends at Different Temperatures

Time (h)	2°C*	2°C**	12°C**	20°C**	28.5°C**
0	20.6	20.6	20.6	20.6	20.6
24	7.7	8.5	5.0	3.9	3.4
48	5.2	6.3	2.7	1.8	1.9
72	4.3	5.3	1.9	1.0	0.9
96	4.0	4.7	1.4	0.9	0.5
120	3.5	4.3	1.2	0.8	0.3
144	3.3	3.9	1.0	0.6	0.3
168	3.2	3.6	1.0	0.4	0.3
192	2.9	3.3	0.7	0.1	0.3
216	2.9	3.6	0.9	0.1	0.1

* Disturbed sample.
**Undisturbed sample.

Conclusion

The moisture exchange between wet and dry portions in the blend was to be very fast in the first two days throughout the temperatures experienced and whether the sample was disturbed or undisturbed. However, the rate of moisture movement between the two portions slowed down, and for maximum, no significant moisture change occured after 5 days.

Disturbance of the wheat blend has been shown to shorten the time required of the blend to reach EMC, i.e., the disturbed sample took 3 days, while the undisturbed sample took 5 days to approach, approximately a steady state.

The temperature has also a great effect on the time consumption to reach the EMC.

The final MC of wet grain remained higher than dry grain in each blend.

The time required for certain MC of both dry (adsorbing) or wet (desorbing) kernels can be obtained by using the following equations:

a) for desorbing wheat

$$MR = \frac{M - Me}{Mo - Me} = \exp - Kt$$

Table 5. Time Required to Reach Equilibrium Moisture Content at Different Temperatures

Temperature (°C)	Time Required to Reach the Equilibrium (h)
2*	72
2**	120
12**	60
20**	66
28.5**	48

* Disturbed sample.
**Undisturbed sample.

b) for adsorbing wheat

$$MR = \frac{Me - M}{Me - Mo} = \exp - Kt$$

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University Training in Agricultural Mechanization in Cameroon

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Abstract

The state of agricultural mechanization in Cameroon is briefly reviewed. The lack of a training programme for managers of agricultural engineering technology, and the shortage of these specialists are identified as some of the major constraints to the advancement of mechanization in Cameroon. A recently introduced university programme in agricultural mechanization in the countly is presented. The main philosophy of the mechanization programme is to provide the graduates with skills for the selection, operation, maintenance and management of agricultural engineering technology. The future of this programme is bright because of its uniqueness in Francophone Africa and also because of the projected demands for the graduates.

Introduction

Need for Mechanization

The economy of Cameroon is primarily agricultural and the key to economic development lies in raising the productivity of the agricultural population. The Food and Agricultural Organization (1990), estimated that in 1989, about 62% of the population was engaged in agriculture. The majority of the farmers practice subsistence farming using human labour and hand tool technology. Eicher and Baker (1982), estimated that for most of Africa, 84% of farmers use hand tool technology, 12% use animal power technology and 4% use mechanically powered technology. This state of affairs applies to Cameroon and has hardly changed over the last decade. The farmers are mostly women, and the farming system is characterized by low productivity per unit area and low production per farmer. With an estimated population of 11.5 million in 1989, and the total area of land under arable and permanent cultivation of about 7 million ha, the national average holding per farmer was about 1 ha. This figure is probably much lower considering that agro-industrial plantations constitute a significant part of the cultivated area. The productivity per unit area for cereals is about 1 t/ha (FAO, 1990). This figure is low, even when compared to the average production of all developing countries of about 2.3 t/ha.

Cameroon is presently self-sufficient in most staple foodstuffs with surpluses for export to neighbouring countries. However, with the population increasing at a rate of 3.23% year (Ministry of Plan and Regional Development, 1986) and a decreasing percentage of the population engaged in farming as a result of the rural exodus of the youth, this food self-sufficiency will not continue for long if the productivity of the farmers does not improve. The percentage of the population involved in farming decreased from about 70% in 1980 to 62% in 1989 (FAO, 1990). During this same period the area of farm land under cereals, which are the major staples of a large portion of the country has decreased by about 20%.

The low productivity and the drudgery in traditional agriculture makes this activity very unattractive to Cameroonian youth. To raise the agricultural productivity so that surpluses can be used for the development of agro-industries, steps must be taken to attract men and youth to farming. This is possible only if the farmers can comfortably produce crops with surpluses for the market. In order to achieve this, the yields will have to be improved through better inputs, management and storage and processing and/or increases in cultivated area.

Significant increases in agricultural productivity will be possible only if there is a corresponding input of trained manpower in agricultural mechanization. Until very recently, there was no training programme in agricultural mechanization at university level in Cameroon. This programme was introduced during the 1989/90 school year at the Dschang University Centre.

Dschang University Centre

The Dschang University Centre (CUDS), was established in 1977. It is presently the only institution in the country for training university graduates in agriculture. When established in 1977, CUDS was an amalgamation of two existing institutions; the National Advanced School of Agriculture (ENSA) and the Institute for Agricultural Technology (ITA). ENSA offered a five-year programme leading to the "Ingenieur de Conception" diploma, while ITA offered a three-year programme for training officers for immediate practical work in the field and granted the "Ingenieur de Travaux Agricoles" diploma and, an Agricultural Technician diploma. The ITA Programme has been phased out, while the last batch of students in the ENSA programme will graduate in 1993. Beginning with the 1989/1990 academic year, all degree students admitted into the university, entered a four-year Bachelor of Science Degree Programme with five options of specialization: agricultural mechanization; animal production; crop sciences; economics and rural sociology; and forestry, water and wildlife.

Prior to the start of the four year BSc programme, there was no programme at all in agricultural mechanization in Cameroon. A department of agricultural engineering existed but it offered service courses to students undergoing the ENSA and ITA programmes. The first batch of students in the agricultural mechanization option will graduate in July 1993. The programme in agricultural mechanization presented in this paper is the only one in existence in Francophone Africa. There is one university programme in agricultural engineering in Francophone Africa located in Ouagadougou, Burkina Faso but the primary area of interest is soil and water management. The graduates from Burkina Faso do not meet the needs of specialists for managing existing agricultural engineering technology.

The Dschang University Centre has been modeled as a Land Grant University and, consequently, has teaching, research and extension missions. All students in the BSc. programme take common courses during the first two years, and move into the different options during the third and fourth years. Admission into the university centre is based on an annual competitive examination. Following the bilingual nature of Cameroon, courses are delivered in either English or French according to the competence of the instructors concerned. Students equally work and write their examinations in either of the two languages they prefer.

The aim of this paper is to highlight the need for training in agricultural mechanization in Cameroon, and to describe the present and future efforts at training specialists for applying existing agricultural engineering technology at the Dschang University Centre.

Philosophies of the Programme

The BSc. programme is designed to integrate theoretical instruction with applied "hands on" education with emphasis on practical work, such that graduates can be useful immediately after graduation. As shown in **Table 1**, 66% of the total contact hours during the entire programme is devoted to practicals. In the third and fourth years, when the students are in the various options, the proporation of time allocated for practicals increases to 75% for the agricultural mechanization programme. During the first two years, students are given a solid base in the basic sciences as well as fundamentals in general agriculture. During this period, 27% of total practical contact hours are allotted to farm practice. Students are allocated individual plots and are supervised by appropriate depart-

Table 1. Distributionof Contact Hours into Theory and Practical for Students in the Agricultural Mechanization Option

Class	Contact Hours			Percent of Total Hours Used for Practicals
	Theory	Practicals	Total	
First Year	455	600	1 055	57
Second Year	458	602	1 060	57
Third Year	390	730	1 120	65
Fourth Year	215	1 090	1 305	84
Total	1 518	3 022	4 540	66

Note: The hours for practical include 160 h of field practicals in the each of the first three years and 800 h of industrial training in the fourth year.

Table 2. Distribution of Contact Hours by Disciplines for the Entire Programme

General Studies (languages, physical education, seminars)	455
Management and Humanities (Economics, sociology etc)	495
Basic Sciences (mathematics, chemistry, biology and physics)	635
General Agriculture (crop and animal production, soil science)	995
Agricultural Mechanization	1 860
Total	4 540

ments to grow vegetables during the dry season and field crops during the rainy season. Students also carry out long duration field practical work. In each of the first three years, students undertake a month long field practical exercise to appreciate the life and agricultural production in the rural areas, and also an understanding of some aspects of agricultural mechanization. The second semester of the fourth year is devoted entirely to industrial training, where students are sent to agro-industries to study their functioning and also to be assigned specific responsibilities in the production process of the organization.

From **Table 2**, out of a total of 4540 student contact hours for the agricultural mechanization programme, 41% is in agricultural mechanization. Basic agriculture and agricultural related or required courses account for about 50%. The graduates from the programme are, therefore, agriculturalists with a strong bias towards the management of agricultural engineering technology.

Many attempts have been made to enhance the adoption of agricultural engineering technology in Cameroon. These have included; the establishement of large scale mechanized projects, the creation of government owned machinery hire services, and the uncontrolled importation of farm equipment for small and large scale farmers. Most of these attempts have either failed to meet their desired results or have had little impact on agricultural production. Many reasons can be advanced for this lack of success, but the following reasons have contributed to the failure; the equipment used have been frequently unsuitable for the local conditions, and equipment and structures are usually poorly operated, maintained and managed. The unsuitability results from the wrong selection of the equipment for the job, sub-standard equipment or the machines not designed to withstand the heat, dust and humidity of the tropics. Because

APPENDIX — Courses for the Agricultural Mechanization Programme

Courses	Number of Hours
First Year	
Cell Biology	75
Chemistry (Gen., Mineral and Organic)	105
Mathematics	60
Geology	60
Introduction to Agriculture	60
Communication Techniques	30
Physics	60
Meteorology and Climatology	45
General Economics	45
Rural Sociology	45
Farm Practice	160
Bilingual Training	60
Sports and Physical Education	60
Conference and Seminars	30
Field Practical (1 month)	160
Sub-Total	1 055
Second Year	
Biochemistry	60
Plant and Animal Physiology	75
Plant and Animal Biology	65
Genetics and Evolution	30
General Pedology	30
Statistics and Computing	60
Introduction to Agricultural Economics	45
General Ecology	30
Introduction to Forestry	30
Introduction to Rural Extension	30
Technical Drawing 1	20
Introduction to Agricultural Engineering	40
Microbiology	45
Human Nutrition	30
Farm Practice	160
Bilingual Training	60
Sports and Physical Education	60
Conference and Seminars	30
Field Practical (1 month)	160
Sub-Total	1 060
Third Year	
Common Courses	
General Agronomy	65
Agro-climatology	15
Agricultural Experimentation	30
Soil Classification	30
Introduction to Surveying	30
Introduction to Micro Computing	20
Agric. Machinery and Rural Construction	35
Special Problems in Agric. Production	15
Environmental Protection	20
Research Methods	15
Agricultural Marketing 1	25
Extramural Activities	40
Sports and Physical Education	60
Optional Courses	
Technical Drawing II	40
Energy and Power in Agriculture	50
Rural Construction	60
Workshop technology I	110
Intermediate Surveying	30
Agricultural Machinery	60
Water resources Management	50
Crop Drying and Storage	50
Computer Programming	30
Development and Technology Transfer	25
Photo-interpretation and Teledetection	25
Conferences and Seminars	30
Field Practical (1 month)	160
Sub-Total	1 120
Fourth Year	
Common Courses	
Public Administration	15
Agro-forestry	20
Project Analysis	25
Soil Conservation	25
Developing and Evaluating Agricultural Extension Programmes	25
Farm Management and Accounts	30
Extramural Activities	30
Sports and Physical Education	30
Optional Courses	
Agricultural Process Engineering	60
Irrigation and Drainage	60
Rural Electrification	45
Agricultural Machinery Management	30
Professional Practice	100
Conferences and Seminars	15
Industrial/Field training (5 months)	800
Sub-Total	1 305
Grand Total	4 540

of these reasons the breakdown rate of equipment and structures is very high.

The above situation suggests the need for specialists who can adopt and adapt existing appropriate technology for use by the local farmers as well as the proper management of agricultural mechanization programme at the Dschang University Centre is, therefore, to give a rudimentary foundation in basic engineering principles, and emphasize the selection, operation, maintenance and management of agricultural engineering technology. The graduates will be capable of carrying out simple designs and constructing agricultural equipment and structures from existing designs using local materials.

Material and Human Resources

The development of the programme in agricultural mechanization has taken place with the support of a USAID Agricultural Education Project (AEP). There are presently eight faculty in the department, seven of whom have received grants from this project for further studies in the United States of America. The faculty are distributed according to specialization as follows; one in power and machinery, two in soil and water, two in electric power and processing and three in structures and environment. There is a recurrent advisor from the University of Florida, USA who will spend one month per year in the department for the next five years. The common and option courses offered by the department in the BSc programme add up to 995 contact hours per student. However, the total number of formal contact hours for the faculty is 1268 because large classes are broken down for practical sessions. The average number of formal contact hours per faculty per year is, therefore, about 160.

The USAID project has provided funds for the purchase of laboratory equipment for all the disciplines in agricultural engineering amounting to about a quarter of a million US dollars. The equipment has been used to furnish the following facilities; a modern and well-equipped metal and wood workshop used for teaching and research, and a drawing office to accommodate 20 students. An existing building is being remodelled to house the crop processing and storage laboratory and the soil and water laboratory, while and outdoor facility for irrigation and drainage practicals is also being developed. There is presently no laboratory in farm power and machinery and so the workshop and the drawing office are used to house agricultural machinery and an extensive collection of cutaway models and teaching aids in power and machinery. The department has two micro-computers, one complete with a digitizer, plotter and software for geographic information systems and computer aided design.

In addition to the facilities available in the department, other resources exist on campus which are also used by students in the agricultural mechanization option. These include equipment at the university farm, soil science laboratory, cartography laboratory and the university microcomputer laboratory. The available facilities dictate that the maximum number of students in the programme be limited to 20/year. There are currently 18 students in the first batch expected to graduate in July 1993.

Employment Opportunities

The Cameroon government is concerned about increasing the productivity of the dwindling percentage of the population involved in farming. For this to be successful there will be a need for personnel who can apply agricultural engineering technology to multiply the effectiveness of Cameroonian farmers. Hence there will be a great need for training in agricultural mechanization well into the future. Graduates will find employment as extension specialists, farm managers, agricultural equipment dealers and teachers of agricultural mechanization.

Extension specialists — These are extension specialists in agricultural engineering for small farmers. They could be recruited directly by the state or by government agencies involved in agricultural development in the country. In this capacity, they will advise farmers on the selection of suitable farm equipment and their safe and efficient use; design of simple irrigation systems and the evaluation of farmers irrigation systems; design or selection of simple farm structures for crop storage, housing, soil and water management and design and construction of simple civil engineering works around the farm. These extension agents will provide a valuable link between researchers in agricultural engineering and farmers.

Farm managers — They will manage agricultural mechanization systems in agro-industries and large farms, either privately or state owned. Such systems will include: workshops or agricultural equipment pools; storage structures for crop and equipment; soil and water management and equipment for handling, grading and processing of agricultural products.

Agricultural equipment dealers

— With the uncontrolled importation of agricultural equipment which is frequently inappropriate for local conditions, graduates of the programme will make good dealers of agricultural equipment. They will be in an excellent position to stock appropriate equipment and advise farmers on their selection for specific purposes.

Teachers of agricultural mechanization — They will teach in colleges of agriculture for the training of agricultural technicians.

Problems with the Agricultural Mechanization Programme

(a) Most of the courses taken by all students in the first two years are adequate for the agricultural mechanization programme. However, there are a number of courses which are either irrelevant or covered in too much detail. Some of these are; cell biology, genetics and evolution plant biology and physiology.

(b) The permanent faculty in the Department of Agricultural Engineering are all relatively young. Of the eight faculty, three are assistant professors while the remaining five are all lecturers. There is, therefore, a lack of senior, experienced faculty to provide academic leadership in the department. This problem is alleviated periodically by the use of advisors provided by the USAID project from the university of Florida, and professors on sabbatical leave from other universities.

(c) Lack of adequate laboratory space especially for farm power and machinery. This problem should be solved within the next year as other academic departments move to a new facility constructed by the USAID project.

(d) Shortage of faculty in the area of power and machinery and a lack of support personnel. There are presently no laboratory technicians assigned to the department. As a result professors spend a considerable part of the time carrying out routine exercises required for the preparation of student practicals.

Future Plans

The programme presented in this paper was designed based on the problems experienced in the introduction of agricultural engineering technology in Cameroon, and on the perceived role of specialists in this area. The programme cannot, therfore, be expected to be perfect. When the first graduates get to the job market, it will be imperative to conduct a study to find out their acceptability in various jobs, and to modify the programme to meet the real and changing needs of farmers.

Students in the ENSA and ITA programmes pay no fees, receive an allowance from the state, and are guaranteed a job on graduation by the government. The situation with the students presently enrolled in the BSc degree programme is different in that, the graduates are not guaranteed jobs. With the economic depression the country is experiencing, there are indications that in the near future, university students will also be required to pay fees. To sustain the programme, students from neighbouring countries in the region will have to be attracted to the university. This implies that the philosophies of the agricultural mechanization programme will be modified to reflect a regional need and not only the demands of Cameroon.

Conclusion

The lack of a training programme for managers of agricultural engineering technology, and the shortage of these specialists are some of the major constraints to the advancement of mechanization in Cameroon. This suggested that there was a great immediate need for a university level programme in agricultural mechanization. The programme described in this paper will produce graduates who can satisfy this need and who will have no difficulty finding a job on graduation.

The future of the agricultural mechanization programme is quite bright because of the importance of agriculture mechanization in Cameroon. This programme is the only one in Francophone Africa and hence has the potential of attracting students from these countries. Hence there will be a demand for graduates of the programme well into the foreseeable future.

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Agricultural Mechanization in Nepal: A Case Study in Two Selected Districts

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Abstract

The present study analyses the status of agricultural mechanization in Nepal along with in depth assessment of existing farm tools, implements and machineries (TIM) used by the farmers; the identification of the problems as encountered by the local TIM producers and users; and the determination of training and credit needs. Furthermore, focus is laid on the identification of the farmers' needs for different farm tools and implements and the promotion of local products for its supply.

Introduction

In Nepal, the demand for simple traditional agricultural tools and implements is mostly met by the rural artisans/blacksmiths spread throughout the country. A few private manufacturers also produce and sell agricultural tools and implements on a job-order basis. A significant number of farm tools and implements have also been imported from abroad to meet the local demands.

The government-owned Agricultural Tools Factory (ATF), established in 1964 at Birgunj (Parsa District), which is a National Institute (NI) of Nepal engaged in the promotion of agricultural mechanization in the country and is a member institute of the Regional Network for Agricultural Machinery (RNAM), produces a significant number of improved farm tools and implements. However, it has been realized that most of the improved tools and implements, which are being produced by the factory, could also be produced by the local manufacturers, if necessary training and other supports are provided. Hence, in order to rationalize production and to substitute the import of farm tools, the rural artisans/blacksmiths and other small scale manufacturers of farm equipment, should be encouraged so that these small enterprises can take over the manufacture of some of the simple farm tools and implements, and ATF should concentrate attention on the production of higher value and even mechanically complex machines. But before making efforts to manufacture more sophisticated implements by the factory, it is felt necessary that a survey of indigenous agricultural implements used at the moment by the farmers must be undertaken. It would be easier, at least as a first step to assess and improve the existing indigenous implements in order to increase their efficiency and thus give something to farmers which is within their means.

Realizing the fact that manufacturing of sophisticated machines is not justifiable without studying farmers' needs for such farm tools, implements and machines, it was proposed that a survey be conducted on TIM manufactured by the local manufacturers and used by the farmers at different stages of crop production. Hence, a survey/study was conducted in this regard by the Agricultural Project Services Centre (APROSC), in October 1991 with financial support of the Food and Agricultural Organization (FAO) as a part of the project on "Strengthening the Agricultural Tools Factory" Birgunj. This paper is based on the outcome/findings of the aforesaid study.

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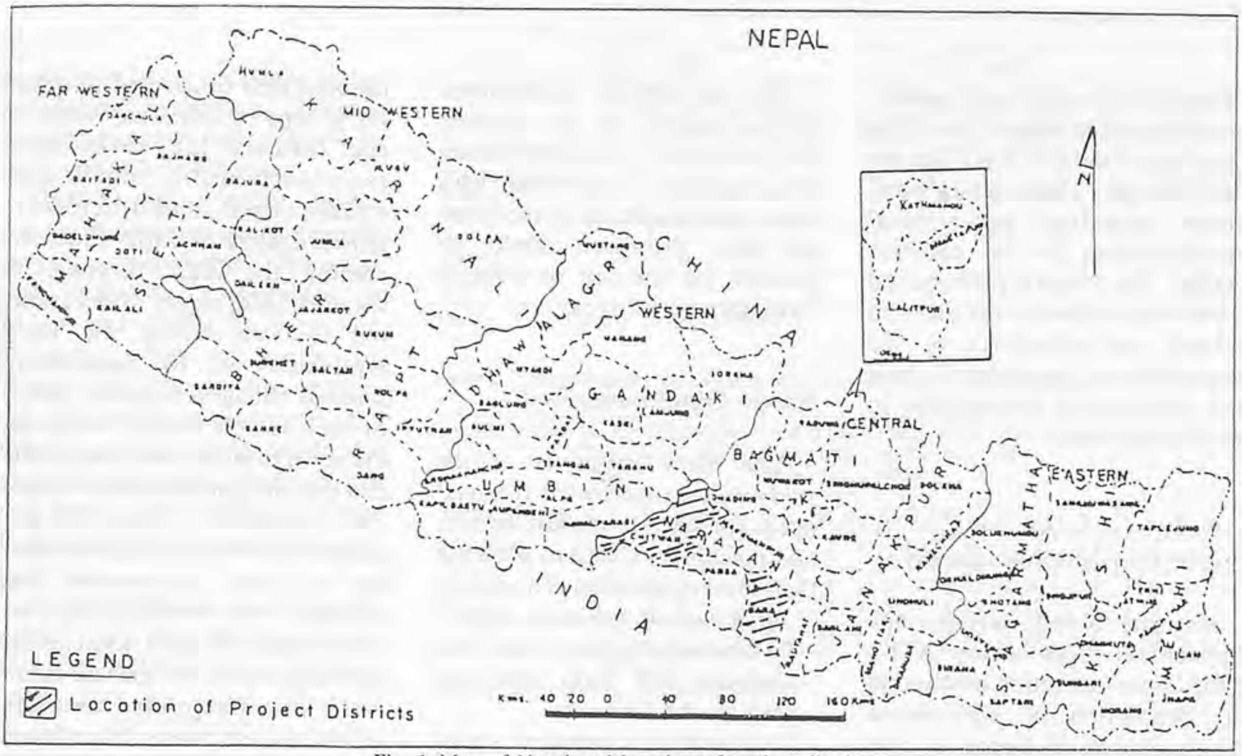

Fig. 1 Map of Nepal and location of project districts.

Agricultural Mechanization: an Overview

Nepal is predominantly an agrarian country. More than 94% of Nepal's total population is engaged in agriculture for their livelihood. On an average, 60% of the gross domestic product and 80% of the country's export come from the agricultural sector. So, the improvement in the agricultural production is the prerequisite for the overall development of the country. In this regard, the improvement of the agricultural production and productivity depends not only on the availability of improved seeds and fertilizers but also on the timeliness of the agricultural operations. The timeliness in the completion of various agricultural operaitons, in addition to labour, depends on the use of modern/improved farm tools and implements.

The past history of farm mechanization reveals that tractors and pumpsets were introduced in the country since early 1960s. However, the process of farm mechanization has remained almost stagnant. Traditional manual tools and animal-drawn implements form the mainstay of agricultural tools in use in the country and the demand of such tools is mostly fulfilled by the village level artisans/blacksmiths. Large farmers take interest to invest in farm machinery like tractors and pumpsets. About 97% of all available farm power use in farming came from draft animals and cattle. The remaining 3% was supplied by mechanical power units. In terms of the ratio of horsepower (hp) to net cultivated area, of the total 2.88 hp/ha, 2.8 hp comes from draft animals and 0.08 hp comes from the mechanical sources. In terms of density, there were about 4 000 draft animals/1 000 ha of cultivated area, while there was less than one tractor/1 000 ha of cultivated area. Thus, even after three decades of the introduction of farm machinery, their contribution to total farm power is still negligible.

Several reasons can be attributed to the slow progress of agricultural mechanization in Nepal. The country's topography makes it difficult for the use of mobile machinery on the steep slopes of hills and mountains. Lack of accessible roads has further aggravated this problem. It is for this reason that many of the available farm machineries are found in the southern plains (Tarai) of Nepal. Small and fragmented land holdings, high capital investment, abundance of unemployed and underemployed labour, low purchasing power of the farmers, traditional methods of farming, lack of clear government policies, etc. are some other factors hindering the pace of agricultural mechanization in the country.

The agriculture sector has been accorded topmost priority by the government in terms of national plan outlay and annual budget. However, since no budget breakdown on farm mechanization is available, no clear priority on farm mechanization can be discerned in terms of budget outlay. Nevertheless, the government's attitude towards farm mechanization based on plan documents and policy pronouncement can be summarized as selective mechanization of farming with labour-intensive technology. The fifth Five-Year Plan (1975-80) for the first time gave a clear policy statement regarding agricultural mechanization in the country. During the seventh plan period (1985-90), emphasis was given to achieve self-sufficiency in the production of agricultural tools and implements appropriate to local conditions.

Institutions Involved in Promoting Mechanization

As mentioned earlier, the Agricultural Tools Factory (ATF), is the major institution involved in the promotion of agricultural mechanization in Nepal. It also conducts research and development (R&D) activities in the field of agricultural mechanization. It manufactures or improves new farm technology and demonstrates it in demonstration field and even at farmer's field. At present the R&D unit is engaged in making farm equipment and machineries, e.g., rice transplanter, multi-crop thresher, maize drill, wheat combine drill (animal-drawn), and zero-tillage seed drill etc.

The Agricultural Development Bank/Nepal (ADB/N) is a major financial institution which provides loan for the procurement of agricultural machines. Credit being provided by ADB/N along with other commercial banks has contributed significantly to the rapid increase in the use of tractor and pumpsets.

The National Trading Limited, a government corporation, is the largest selling agent of agricultural TIM in the country. Besides it, some private agencies, dealers/seller also import and sell agricultural TIM directly to the farmers through their sales depots. The ATF sells its products either directly or through dealers.

The Agricultural Development Office (ADO) is the agency responsible for the dissemination of agricultural TIM along with other technologies up to the farmers field. However, advice to growers on the use of TIM is virtually non-existent.

Study Objectives

The main objectives of the study was to identify the farmers' needs for farm tools, implements and machineries, and to promote their local production. The specific objectives of the study were:

- To determine types of tools, implements and farm machines used by the farmers;
- To identify the technical, social and economical problems faced by the farmers for mechanizing farming operations;
- To suggest improvement in the existing farm tools, implement and machines;
- To conduct survey of artisans/blacksmiths and small scale TIM manufactures, evaluate their products and determine training and credit needs; and
- To suggest ATF on improving tools, implements and machines production.

Methodology/Limitations

Two districts in the southern plain (Tarai), namely; Bara and Chitwan of the Narayani Zone were selected as the study areas[1]. During the selection of the study areas, the ecological condition of the district, availability of mechanization technology and its use were duly considered. The target groups of this study were — the farmer, the rural artisans/blacksmiths, small and middle level manufacturers, sellers/dealers of farm TIM, including the ATF Birgunj. A detailed field survey was carried out by interviewing the farm households in 10 purposively selected villages (research sites) of each sample district — covering seven to eight farm households and one blacksmith in each village. The households were chosen purposively where maximum number of farm implements and machines were owned/used/rented. In total, 150 farm households, 20 blacksmiths, six private small scale manufacturers, and six sellers/dealers were interviewed during the field survey. Interviews were conducted with a pretested, structured questionnaires prepared separately for different target groups. Some enquiries were also obtained from the government and semi-government agencies engaged in farm equipment and machineries matters.

The analytical approach included the identification of factors pertaining to farm TIM utilization and factors constraining their use according to the farmers' need. The analytical framework includes the evaluation of farm TIM locally produced by the rural artisans/blacksmiths, ATF and imported ones from abroad.

Findings and Discussions

Among the households surveyed, 35% lie in the small, 19% in the large and marginal and 27% in the medium farm group[2]. The

[1]Note: Bara and Chitwan districts lie in the Narayani Zone in the Central Development Region of Nepal. Bara is located in the Tarai physiographic region, while the northern part of Chitwan is located in the Siwalik and a small part in the middle mountains. They occupy 1 190 and 2218 km^2 of land area, respectively.

[2]For analytial purposes the households have been classified into marginal, small, medium and large groups based on operated land holdings (a proxy for income) as follows: marginal up to 1.02 ha.; small 1.02 to 2.71 ha.; medium 2.71 to 5.42 ha. and large above 5.42 ha.

proportion of economically active population[3] using farm TIM (especially tractors) constitutes 4% in Bara and 9% in Chitwan.

Paddy, wheat, maize, sugarcane and oil-seeds are the major crops grown in district. The cropping intensity is computed at 181% and 195% in Bara and Chitwan, which are higher by 10 and 14% than the district average, respectively. Compared to the district average yield level; the yield of sugarcane, paddy, maize and wheat has been found higher in the sampled households of both districts.

In the study, it has been observed that, with the use of tractors, per hectare yield of different crops has increased although it was very difficult to isolate yield increase that is due to mechanization alone, because it was introduced with other complementary inputs (e.g., use of higher level of inputs and high educational level).

Draft animals (bullocks and buffalos) were the major source of farm power for agricultural operations (e.g., ploughing, harrowing and threshing, etc.). In some areas, draft animals were retained for safety purpose in case of tractor breakdowns. The average number of draft animal holding in Bara is 1.49 and in Chitwan, 1.15.

In the study areas, 66% of the tractor owners possessed tractors of 35 hp capacity. Farmers preferred tractors of 35 and 45 hp capacity, since they found these tractors quite stable for the dual purpose of farming and transportation **(Table 1)**. The users suggested to the ATF to manufacture tractors with the above mentioned hp range. Most of the tractor owning farmers also possessed diesel engine pumpsets, power wheat threshers, cultivators, disc-harrows and cage wheels **(Table 2)**.

Table 1. Ownership of 4-Wheel Tractors and Power Tillers in the Study Areas by Make and Horsepower

HP/District	Power tiller		4-Wheel tractors							
	10.5 hp		20.hp		35 hp		45 hp		60 hp	
Make	Bara	Chitwan	Bara	Chitwan	Bara	Chitwan	Bara	Chitwan	Bara	Chitwan
Korean	—	3	—	—	—	—	—	—	—	—
Massey Ferguson	—	—	—	—	6	21	7	3	—	—
Escort	—	—	—	—	2	2	—	—	—	—
Belarus	—	—	—	—	—	—	—	—	3	10
International	—	—	—	—	1	4	1	1	—	—
Sworaj	—	—	—	—	—	—	—	—	—	—
Total	—	3	1	—	9	27	8	4	3	10

Source: Field Survey, APROSC-1991.

Table 2. Ownership of Tractors and other Power-Operated Farm Machineries by Farm Groups

Farm TIM/Districts	No. of House-holds (HH)		4-Wheel tractors		Power tillers		Diesel engine pump-sets		Power wheat thre-shers		Power corn sheller		Culti-vators		Disc harrow		Leveller		Cage-wheel		Trailer	
Farm Group	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
Marginal	14	14	1	4	—	2	1	2	2	1	—	—	—	6	—	2	—	—	—	2	—	6
Small	25	27	4	8	—	—	11	8	4	—	—	—	5	8	2	5	—	—	1	5	5	8
Medium	23	18	8	14	—	1	18	2	9	3	1	1	8	15	4	10	—	2	2	6	8	15
Large	13	16	8	15	—	—	9	11	7	3	2	1	8	15	5	12	1	4	4	9	8	15
Total	75	75	21	41	—	3	39	23	22	7	3	2	21	44	11	29	1	6	7	22	21	44

B = Bara; C = Chitwan.
Source: Field Survey, APROSC-1991.

Table 3. Percentage Distribution of Use of Farm Tools, Implements and Machineries in Various Farm Operations

Farm Operations	Manual Tools		Animal-Drawn Implements		Power-Operated Machineries	
	Bara	Chitwan	Bara	Chitwan	Bara	Chitwan
Land Preparation						
— Tillage/Ploughing	NG	NG	78.4	53.9	21.6	46.1
— Harrowing	—	—	85.1	79.8	14.9	20.2
— Puddling	NG	NG	71.5	68.7	28.5	31.3
Sowing/Transplantation	100.0	100.0	NG	NG	—	—
Intercultivation						
— Weeding	100.0	100.0	NG	NG	—	—
Plant protection	100.0	100.0	100.0	—	—	—
Fertilizer/Manure Application	100.0	100.0	—	—	—	—
Irrigation	13.0	16.0	—	—	41.4	28.5
Harvesting	100.0	100.0	—	—	—	—
Threshing, Winnowing and Grading	70.0	73.0	15.0	20.0	15.0	7.0
Transportation	11.0	16.0	55.0	45.0	34.0	39.9
Milling	8.2	12.4	—	—	91.8	87.6
Storage	100.0	100.0	—	—	—	—
Livestock occupation	100.0	100.0	—	—	NG	NG

Note: NG = Negligible.
Source: Field Survey, APROSC-1991.

Nepal's agriculture system is still labour intensive. Hence, besides land preparation (which is performed by animal-drawn implements and tractors), irrigation and threshing (to some extent), all the farming operations were performed traditionally, using manual tools and implements **(Table 3)**.

Sickle, spade, *khurpai* (locally made curved cutting knife) and hand hoe were the common manual tools **(Fig. 2)** possessed by the sample households and among the animal-drawn implements, wooden plough, mouldboard plough and ridger were owned with an average of one plough per farm household.

The farmers with small land holdings could not maintain high technology. They depended on traditional methods or on custom hires for farm power. Among the animal-drawn implements, ploughs and tyre carts were cus-

[3]Population aged 10 years and above excluding disabled persons.

tom hired. About 35-40% of the total annual use hours of the ploughs owned by the sample households were rented-out. Among other power-operated machinery, pumpsets, power wheat threshers, power corn shellers and tractors were custom hired for more than 70% fo the total annual use hours **(Table 4)**.

The 4-wheel tractors were found to be used for dual purposes of on-farm operations (tillage, ploughing, harrowing) and transportation. They study reveals that out of the total average annual use hours of the tractors, which is 1 305 h in Bara and 1 421 h in Chitwan; the use of tractors in on-farm operations is 46% in Bara and 52% in Chitwan; whereas the use of tractors in transportation activities is 54% and 48% in Bara and Chitwan, respectively **(Table 5)**. Custom hiring for both on-farm operation and transportation was widely practised in the study areas.

Farmers perceived the use of power-operated technology positively as well as negatively. Despite positive aspects of farm mechanization, small/fragmented plot sizes, lack of farm roads, scarcity of TIM during peak periods, poor quality and high cost, lack of spare parts, time consuming procedure for getting loans and high interest rates were some of the major problems of mechanization as encountered by the farmers.

Farmers needed farm TIM which eased labour constraints during peak periods (e.g., transplanting and harvesting). Up to the present time, these operations were completely manually performed requiring 32 and 35 mandays/ha in Bara and 34 and 43 mandays/ha in Chitwan. The operations, if not completed on time, would result in loss of yield and acute labour shortages were experienced during transplanting and harvesting. Similarly, about

Table 4. Renting of Agricultural Implements and Machineries in the Study Areas

Agricultural TIM	One's own use		Custom hiring		Total	
	Bara	Chitwan	Bara	Chitwan	Bara	Chitwan
Animal drawn plough	220 (59.5)	200 (64.5)	150 (40.5)	110 (35.5)	370 (100.0)	310 (100.0)
Tyre cart (ADV wheel Axle)	250 (45.5)	200 (57.1)	300 (54.5)	150 (42.9)	550 (100.0)	350 (100.0)
4 Wheel tractors	164 (12.6)	197 (13.9)	1 141 (87.4)	1 224 (86.1)	1 305 (100.0)	1 421 (100.0)
Diesel pumpset	50 (200.0)	40 (17.4)	200 (80.0)	190 (82.6)	250 (100.0)	230 (100.0)
Power wheat thresher	4 (2.6)	7 (12.3)	150 (97.4)	50 (87.7)	154 (100.0)	57 (100.0)
Power corn sheller	10 (7.4)	15 (30.0)	125 (92.6)	35 (76.0)	135 (100.0)	50 (100.0)

Note: Figures in parenthesis indicate percentage of total hours used.
Source: Field Survey, APROSC-1991.

Table 5. Average Annual Use of Tractors (in hours) for Different Operations and Purposes

Operations	Types of purpose/Districts					
	Use on own farm (hrs)		Custom hiring (hrs)		Total annual use (hrs)	
	Bara	Chitwan	Bara	Chitwan	Bara	Chitwan
i) On-Farm						
a) Tillage/ploughing	78	89	479	604	557	693
b) Threshing and others	15	12	25	40	40	52
Sub-Total	93	101	504	644	597	745
ii) Transportation						
Cereal/cash crops and other non-agricultural products	71	96	637	580	708	676
Total	164	197	1 141	1 224	1 305	1 421

Source: Field Survey, APROSC-1991.

Fig. 2 Local hand tools (eg, hill type spade, khurpai, axe, hoe etc.) produced by local blacksmiths and used by farmers at Dahakhani, Chitwan.

Fig. 3 Production shed of a middle-level urban artisan/blacksmith along with the bulk of scrap iron used for producing farm tools, Birgunj, Parsa.

Fig. 4 Production tools (including traditional leather blower) used by rural artisans/blacksmiths, Dahakhani, Chitwan.

Fig. 5 Production tools (including improved leather blower) mostly used by urban artisans/blacksmiths, Baghabana, Bara.

Table 6. Type of Farmers' Need for New/Modified Tools, Implements and Machineries (As Suggested by Farmers)

Respondence (%)	Types of Agricultural TIM Needed: Bara	Chitwan
More than 50%	Paddy transplanter (P), Paddy reaper (P)	— —
40-50%	Paddy weeder (P), Paddy cleaner (P)	Paddy transplanter (P), Paddy reaper (P)
30-40%	Sugarcane stripper (P), Sugarcane harvester (P), Wheat reaper (P), Potato digger (A), Paddy, Maize and Sugarcane weeder (A), Harrow (A), Mould board plough (A), Potato digger (M), Corn sheller (M), Paddy thresher (M)	Paddy thresher (P), Wheat, Maize and Oilseed seeder (P), Paddy, Maize and Sugarcane weeder (P), Paddy thresher (M)
20-30%	Leveller (P), Single axle tractor or Power tiller (P), Sugarcane crusher (P), Corn sheller (P), Potato planter (A), Maize planter (A), Ridger (A), Cultivator (A), Duster (M), Paddy transplanter (M), Wheat thresher (M), Wheat seeder (M)	Fertilizer applicator (P), Wheat reaper (P), Paddy, Maize and Sugarcane weeder (A), Disc harrow (A), Mould board (A)
10-20%	Fertilizer applicator (P)	Maize thresher (P), Oilseed thresher (P), Wheat thresher (P), Paddy and Maize weeders (A), Fertilizer applicator (A), Wheat seeder (M), Maize planter (M), Duster and Sprayers (M), Corn sheller (M), Paddy transplanter (M)
Less than 10%		Power tillers and Single axle tracrtors (P), Generator (P), Potato cold storage (P), Potato planter (M), Potato digger (M), Maize weeder (M), Potato weeder (M), Forage chopper (M), Water sprinkler (M)

Note: (P) denotes power-operated machineries.
(A) denotes animal-drawn implements.
(M) denotes manual tools.
Source: Field Survey, APROSC-1991.

Table 7. Details of Equipment Produced at ATF, Birgunj (1985/86-1989/90)

Name of Equipments	Quantity Produced in 1985/86	1986/87	1987/88	1988/89	1989/90
Power-operated Machineries					
Tractor trailers	96	23	40	27	36
Threshers	97	211	84	96	233
Disc-harrows	1	5	2	3	—
Cultivators	41	20	41	9	5
Corn shellers	—	—	—	12	—
Diesel pumpsets	—	—	—	715	1 267
Simple Agricultural Tools					
Pedal paddy threshers	167	281	160	83	149
Wheel axle set for ADV	605	521	499	426	407
Animal drawn disc-harrows and cultivators	240	176	94	46	28
Animal drawn plough	2 127	1 975	3 247	3 066	1 659
Hand maize sheller	432	860	1 226	633	578
Other hands tools	3 972	13 398	13 450	13 411	5 449

Source: ATF, Birgunj.

30-40% of the farmers pointed out the need for power-operated wheat reaper, animals-drawn wheat, maize and oil seeds seeder, potato planter and potato digger, etc. In the hills and foot hill areas, the farmers need improved manual tools and animal-drawn implements (e.g., steel hardened carbon plough share, long lasting spades for gravelled fields, etc.) **(Table 6)**.

Regarding ATF products, the sampled farmers' perception varied to a wide extent. Complaints were cited about low quality of raw materials, defects in design, (e.g., only large size maize could be shelled with the corn sheller, weak handle holder of spade, serious heating problem of the engine head of diesel pumpset etc.), higher cost in comparison to other similar TIM available in the local market and poor after sales services.

Fig. 6 4-wheel tractor with locally made cage wheels-used by a respondent farmer at Rampur Tokni, Bara.

Fig. 7 A farmer engaged in ploughing the land by a 4-wheel tractor with cultivator at Prastoka, Bara.

The Agricultural Tools Factory, Birgunj is the largest organization promoting agricultural mechanization in the country through the manufacture of improved farm TIM. Trained manpower available in ATF can also produce more sophisticated farm machines if requisite training and facilities are provided. Details of equipment produced at ATF during 1985-1990 are presented in the **Table 7**.

Besides the ATF, there are many private middle level manufacturers located in different important towns. These manufactures are involved in the production of manual tools and animal-drawn implements. Some of them were producing power operated machineries. Many workshops provide repair and maintenance services and produce TIM on job-order basis.

Among the problems faced by the private manufacturers are the unavailability of raw materials of good quality at reasonable price, unrestricted import of farm TIM, low level of technical and managerial capabilities, were traced as the major ones.

The rural artisans/blacksmiths produced farm tools and implements on job-order basis or in annual contract basis for which they get either fixed quantity of food grains or cash. They also produced some tools for selling in nearby markets. However, uncertain value of products, manual workshop tools, expensive and low quality scrapmetals, lack of wooden coal, high physical labour demanding profession and low investment, were the major problems faced by them (**Fig. 3**).

The rural artisans/blacksmiths were the main suppliers and repairers of farm TIM (especially manual tools) in the study areas. By virtue of their dwelling in almost all of the villages, and also due to their hereditary adherence to the production of farm tools, they would continue to remain the focal persons to be considered in all plans and programmes aimed at promoting farm mechanization in the country.

The ADB/N is the major financing institution for farm TIM such as 4-wheel tractors, power tillers, pumpsets, tubewell, threshers and tyre-carts, etc. Among the farm groups, large and medium farmers were more interested and had access to purchase power-operated farm machineries. The marginal farmers had no share or/access to the use of credit.

There was no separate institution providing training programme for different target groups or disseminating the technology. Only some of the private TIM importers/dealers or their agents provided some sort of training relating to minor repairs and handling of the machinery at the time of machinery sales.

Concluding Remarks and Recommendations

Although the present status of farm mechanization in Nepal is low, there is a scope for its development. The Tarai, including the inner Tarai and valleys have potentials for the introduction of power-operated mechanical technologies. However, due to undulating topographic features of hills and mountain valleys, the power-operated machines such as power-tillers, single axle tractors, water lifting devices etc. have brighter prospects.

In the Tarai plains where labour is a limiting production factor specifically during transplanting, weeding and harvesting of crops, mechanization of these operations is in great demand.

Mechanization as a positive measure to improve the economic condition, the policy/steps should be taken by the government considering mechanization needs for different classes of farmers and for different agro-climatic conditions. Production, marketing and other supporting institutions for farm TIM should be strengthened and/or established.

There is a need to formulate policies, strategies and programmes in relation to total demand for farm power in agriculture, based on increased production goal designing an appropriate combination of human, animal and mechanical power for specific situations, including technical availability, economical and social objectives. For this purpose, a master plan for agricultural mechanization should be prepared and implemented keeping in view the long term objectives of the balanced agricultural development of the country.

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Status of Supply of Farm Equipment and Future Direction of Agricultural Mechanization in Vietnam

by
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Introduction

Up to mid - 1992, the agricultural sector in Vietnam has been provided with nearly 20 000 tractors (including tractors of the former Soviet Union, Austria, and Japan); 20 000 small two-wheel power tillers (of which 70% were produced in Vietnam), 400 000 gasoline and diesel engines either used in stationary works or mounted on fishing-boats (mostly made in Ho Chi Minh City, Hanoi and imported from Japan and China); 30 000 electrical motors from 2, 8 - 100 kW; 2 000 transformer stations, 7 000 vehicles and hundreds of thousands agricultural machinery with a total power of 4 million hp (of which 0.8 million hp were used for soil preparation); the per hectare rate of power input reaching 0.5-0.7 hp. Electrical capacity provided for agriculture was 1.2 × 10 kWh.

The system of agricultural engineering services for agriculture in Vietnam included 300 agricultural engineering enterprises in districts; hundreds of state farm mechanical teams; 14 factories for farm tractor fundamentally repairing, producing and restoring details of machines; and nearly 200 workshops for small-scale repairing and maintaining of machinery. The system of providing agricultural engineering spare parts was established and located in the regions, provinces and districts. The system of training includes over 30 technical secondary schools and other schools for technical workers training. In agricultural universities in the country, there are agricultural engineering faculties. Research organizations network include the Vietnam Institute of Agricultural Engineering (VIAE), Research Center of Agricultural Engineering and Food Industries (Ho Chi Minh city) and Center for Testing Agricultural Machinery.

Most of the infrastructure, equipment, facilities and technical bases of the agricultural engineering sector are out of date and backward in technology.

Supply and Utilization

Under the mechanism of assignment delivery quota to individual farm households which are now considered as a basic unit, autonomy in its economic making decision, and the land has been entrusted to individual farm household and worker for long-term exploitation. The provision of farm equipment is now directed not only to the cooperatives, productive collectives, state farms, or agricultural engineering enterprices as before but also to other various economic components in which farm households and workers are the key objects of concern. The production in agriculture now shifts to the gradual development of agro-forestry, fishery, livestock husbandry, and also, farm product processing and subsidiary occupations. In order to play an effective role in the establishment of a new rural area and rural industrialization, the agricultural engineering sector should direct its supplying activities not only to the farming branch but also gradually to several other economic components.

In order to know better the performance of the Vietnamese farmers, a survey was made among farm households and the results obtained show that:

1. The average land holding per household in the Northern provinces is 1 620 m^2 per labor and 2 916 m^2 per household. In the provinces of the Mekong river delta, this is 5 000-20 000 m^2 per household.

2. The per capita annual income differs by household categories. The rich households account for 15-20%, the fair ones: 58-68% and the poor ones: 17-22% of total households. The percentage of farmers having fund

over 3 500 000 dong is 15-20%.

The investment on expensive farm machinery by the majority of farm households has faced difficulties. However, it is observed that in the rural area, hundreds of thousands of households can afford equipment to engage in contractual services for other neighbouring families like power tillers, tractors, tilling machines and transportation vehicles.

Farm households having low and average income require improved farm implements, new type of tools with prices below 200 000 dong. Rich households and the families engaged in service work in the countryside with greater affordable performance require small mechanical power and machinery, a minority of them could purchase big tractors. The State and collective production units now perform their managerial skills not on the whole of farm equipment but only on some important ones for the most essential operations of production (big size water pumps and tractors). For the rest of these farm equipment, the farm households and workers can own them through the ways of "pricing, and endorsing."

The Agricultural Engineering and Food Processing Industries

During the past years, the agricultural engineering sector accomplished the following:

1. Making contribution in the land reclamation, field transformation, catering for planting hundreds of thousand ha of industrial crops (particularly coffee and rubber) in the Western Plateau and Eastern area of the South, expanding double cropping practices (winter-spring and summer-autumn crops) in Mekong river delta. During only a period of 4 years (1988-1992) nearly 200 000 ha were transformed in this delta contributing to increased total rice output of the region reaching 4 million t, bringing the total annual rice output of the whole country to nearly 23 million t.

2. Apart from taking full advantage of animal draught, it should be noted that the agricultural engineering sector promoted and made use of all kinds of equipment in the whole country, including power tillers, and tractors. Nearly 1.9 million ha or 21.2% of the total planted area of the country were done yearly by power tillers and tractors (from 1.7-1.85 million ha), in which, it was 29-34% and 40-45% at the Red river and Mekong river deltas, respectively.

3. A system of various sizes of water pumps under the management of the agriculture sector together with equipment from the state hydraulic works ensured active irrigation and drainage over 5 million ha of planted area, increasing over 800 000 ha as compared to the year of 1985.

4. The mechanization of harvesting and processing farm products ensured rice threshing for 3 million ha; rice milling, over 10 million t for domestic use and 1.5 million t for export; grinding of millions of tons of products for feed, etc.

Applied Technical Progress to Agricultural Mechanization

A great deal of technical progress has been applied to agricultural production. Below are several main achievements:

1. A range of axial flow pumps of inclined type with output ranging from 3, 4, 8, 20 to 75 kW has been introduced to agriculture which amount to tens of thousand units to replace the centrifugal water pumps. In areas of low topography with the water column below 10 m, the capacity increases by 1.5-1.8 times and special energy consumption decreases nearly 30% and they are more convenient and efficient since they do not require priming. Thousands of axial flow pumps of inclined-type have been operating in the provinces of Hatay, Thaibinh, Namha, Hai hung, Ninhbinh and Habac. They help to save millions of kWh yearly.

2. A set of newly-developed tools and implements with simple structure, low cost, giving high labour productivity used in harvesting, plant pest control, and processing has been transferred to consumers.

3. A system of implements and machinery for processing food, foodstuff, and products for feed have been developed like: rice millers, a range of grinders for feed, an integrated set of implements and machinery for extracting vegetable oil, for processing tubes of dryland crops, drying farm products, and processing noodle for food. These kinds of implements and machinery are simple in construction, easy to manufacture, suitable to the production scale of individual or group of households.

4. Some technical progresses on small mobile power such as: small simple power tiller MKX-4, floating power tiller MKT-1, introduction of gasoline and diesel engines of small sizes (4, 6, 9 and 12 hp). This progress satisfactorily meets the need of farmers. The newly-developed mobile powers as mentioned above (3-4 kW and 8-9 kW) have simple structure, are easy to fabricate and suitable to the farmers' use with regard to capacity and scale.

Future Direction of Farm Equipment

The strategic goal of the

Government for the year 2000 is to strive for overcoming the threshold of poverty and increase the average production per capita to 400-500 US dollars per year. The agricultural sector should ensure a per capita rate of 350-360 kg of food, 18-20 kg of meat, and 8-10 kg of sugar. The labor force in the rural areas will be 35 million people accounting for 65% of the total labor force in the country. The rate of labor force in farming should decrease from 70% to 60% as compared to the total farm labors. The non-farm labor portion will increase from 4% in 1992 to 15% of total agricultural labor force till the end of 1995.

In order to achieve the above targets, the agricultural engineering and food industries sector should stress intensive farming, multiple cropping, increased yield and total agricultural output, protect cultivation, increased farm products quality, producing more marketable farm produces which are valuable for domestic use and for export, catering for forestry and fishery production and other occupations, gradually realizing rural industrialization, contributing to building a new countryside. An urgent need now is to furnish the agriculture with appropriate source of power; the total numbers of engines from 4 to 33 kW required for supplying reaches 15 000 units per year while the local manufacturing industry can ensure only about 40% of the demand. Below are several kinds of engine that are needed by farmers and non-farmers alike.

1. Engines of 22-33 hp (like Japanese Yanmar type) for fishing boats (number of engines as required: tens of thousand units) while the local manufacture could ensure only 20-30% of the demand.

2. Gasoline engines (like American Kohler type or Italian Lamborghini type) for farm households (number of engines as required: thousands of units). If the Vietnamese-Italian joint venture in the engine manufacture is successful, 500-800 units (5-7 hp) could be certainly provided that will satisfy partly cultivation, and stationary work and processing.

3. The electrical energy sources in Vietnam (especially hydroelectric) are rather abundant. Due to the shortage of small motors for households use, therefore, annual demand on the motors and generators reaches 10 000-20 000 units with the output from 0.5-2 kW.

In order to achieve the objectives above priorities are given as follows:

1. Continue carrying out mechanization of farming, livestock husbandry; subsidiary occupations in rural area, forestry and aquaculture and equipment for life improvement towards a more progressive countryside.

2. Give priority to the mechanization of processing food and foodstuffs, making special considerations on quality of processed products; expanding handicraft activities; bringing into full play the capacity of traditional professions for export, and developing industries for processing of commodities for export like cocoon silk, rubber, coffee and tea.

3. In farm mechanization, priority will be given to the operations like tillage irrigation and drainage, pest and disease control, rice threshing, cleaning, separating, drying, storage and transportation in the countryside.

4. In livestock mechanization, give priority to feed processing, paying much attention to supplying small size machinery.

5. Concern will be paid to the structure and the rate of supplying of powers for the surplus-producing regions. This largely depends on the social-economic-characteristic of the region. In general, the power for non-farm activities in the countryside is about 3 billion kW with the total consumption of electrical energy of about 5 million kWh. On the average, in the branches of rural industry and rural occupation development, the rate of power input (regarding only the engine and motor sources to be supplied) will be 0.32-1.43 kW per labour. The rate of total power input from all sources will reach 0.96 kW per worker.

In farming, the rate of power input per hectare is 0.56-15 kW and the average rate for the whole country is 0.71 kW/ha. The regions requiring high intensive farming level (like the Mekong river delta and the Red river delta) and cultivating industrial plants for export (Eastern area of the South, Western Plateau) have higher rate of power input.

The rate of furnishing power (by output size) appropriate for Vietnamese agricultural production is as follows:

- Power of 35-36 kW output : 20%
- Power of 8-9 kW output: 48%
- Power of 3-4 kW output: 32%

Research Work and Development of Improved Technologies

1. Emphasis is placed, first of all, on the areas and regions which require intensive cultivation for increased crop yield, total food output and quality of agro-products, thus contributing to increasing labour productivity and offering much more employment in rural areas.

2. Basic research and development in agricultural mechanization like: relationships of soil-machine, plant-machine, and material-metal. Establish and

study experimental models in order to reduce necessary labor, energy and total cost in scientific research.

3. Improvement of technologies in carrying out the design, manufacture of a system of implements and machinery catering for the operations of agricultural production like land preparation for seeding and transplanting, plant pest control, harvesting (including combine harvester and the machines for harvesting food crops) and other postharvest operations like processing agro-products with high quality, the equipment for distilling ethereal oil, and other machinery for processing products for export (like tea and coffee) with economical energy consumption. In addition, research should emphasize the technology and equipment for drying agro-products, particularly, summer autumn rice in South Vietnam as well as agro-products for export.

4. Studies on the design, manufacture and introduction into production of simple power tillers and tractors with output ranging from 3-4 kW to 10-15 kW, suitable to technological conditions and the operational skill as well as the possibility of farmers and the services contractors.

5. Study on the design, manufacture and stablishment of a range of water pumps with high lift (from 10 to 25 m) for use in mountain regions and highlands using the power sources from 3 to 55 kW. Carry out experimental study on the improvement of existing big pumps (from 200-500 kW) in order to replace the ones that are old. Special simple pumps catering for the people living in remote areas which are short in energy will also be studied, designed, manufactured and popularized.

6. Study on the restoration of worn-out machine details, machine components of high accuracy standard of tractors used in agricultural production, reclamation, digging, exploitation (like: system of hydraulic pumps). Studies also should be made on the technology and new material in the restoration process of machine details like the technology of plastic coating. The study on determining economic efficiency in the provision of implements and machinery for various components, including households, services contractors and farms.

Making use of available existing improved technologies in the country and the appropriate technologies from abroad, transferring early these technologies to the regions facing difficulties in production and living but they have great potentials which have not been exploited like the highlands, mountain areas and remote areas where the ethnic minority are living.

Some Recommendations

In order to develop and strengthen the serving capacity of the agricultural engineering sector, it is necessary to realize a series of measures regarding investment funding, policies releasing (credit, bank, tax, import and export). Emphasis should also be placed on the international cooperation issues:

1. Increase the international cooperation among the scientists in agricultural engineering in the world, particularly in the regional countries having similar natural (climate, land) and social conditions to Vietnam. Extending the exchange of materials, experience and information in the field of agricultural mechanization.

2. Promote joint collaboration between the scientists of Japan and Thailand and the Vietnam Institute of Agricultural Engineering, in particular, and the Vietnamese agricultural engineering sector, in general, in the design, joint manufacture of agricultural prototypes appropriate to the humid tropical condition and to the environment of Vietnam.

3. It is proposed that scientists of the two countries (Japan and Thailand) will be looking for sources of financial support in order to help in instructing, training, holding special seminars, upgrade the new knowledge in research, and development of appropriate implements and machinery for agriculture and food industries in Vietnam as well as in Japan and Thailand. ■■

The Present State of Farm Machinery Industry

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Outlook of Agriculture

Trend of Agriculture

In 1993 Japanese economy is continuing to be a business recession as well as last year.

In 1991 agricultural total products was ¥7 900 billion it occupied 17% of GNP. The imports of agricultural products are on the increase. In 1992 the imports reached ¥29 550 billion, which means that Japan is the greatest food importing country. In Japan, feed cereals, soybean, wheat and so on depend on the imports from foreign countries. Self-sufficiency ratio of cereals was under 30%. This figure is the low rate of all the advanced countries. On the other hand, agricultural exports was ¥1 370 billion.

Population mainly engaged in farming in 1992 decreased to 3 570 000 persons. It was 5.5% of total working population. Farm houses has decreased rapidly; now are 3 644 000 farm houses. And, commercial household was 2 787 000 (76%) farm house, but full-time typed farm house was only 450 000 (16%).

Arable land was 5 120 000 ha in 1993, which decreased by 1.0% over the previous year. Arable land per one farm family was about 1.4 ha very small.

Agricultural income of farm household (commercial farm households) in 1992 was ¥8.82 million, but agricultural income was only ¥1.43 million.

In Japan, food life has veried since 1970's. While, rice, oranges, milk, eggs and so on have been overproduced. Food industry has developed. In such surroundings, the GATT settlement require Japan to have more competitive power. In Japanese agriculture, it is requested to reduce production cost, increase people destined to bear agricultural production, produce various products satisfying consumers' need, and to realize agriculture keeping the earth favorable.

Trend of Farm Mechanization

Agricultural mechanization in Japan has remarkably progressed in the field of low land rice, chief crop, in a short period since 1955. Thus, consistent system of low landrice has been completed. 99% of rice transplanting, 99% of rice harvesting and 98% of rice drying have been mechanized. As to rice, working hours per 10 a decreased to 39.6 hours, they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be largersized, higher-efficient and more commonly used. In addition, farm machinery for field crops and livestock farming is being developed and improved, which had been lagged behind so far. Especially, concerning to vegetable mechanization has been high. Above all, vegetable-planting machines. Whatever types it may be, farm machinery is expected to be invented and improved positively from various points of view, such as performance ability, safety and cost reduction.

Followings are the number of popularization of farm machinery as of Jan. 1, 1994: riding tractor reached 2 006 000 units; walking tractor 1 669 000; rice transplanter 1 834 000; head feed combine 1 149 000 (**Table 1**).

Shipments of major farm machinery in the domestic market in 1993 are as follows: riding tractor reached 82 000 units (those under 20PS were 28 000; those 20 ~ 30PS 370 000; 30 ~ 50PS 11 000; over 50PS were 600); walking tractor 170 000; rice transplanter 80 000; power reaper 23 000; combine 57 000 (standard types were 298); grain dryer 51 000; huller 33 000. A safety cabin and a safety frame for tractor which are devoted to guarding operator increased sharly. This shipment was 53 000 units (**Table**

Table 1. Major Farm Machinery on Farm

Unit: Thousand

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1986	2,554	1,834	2,098	—	—	—	1,150	—
1988	2,674	1,985	2,199	1,408	1,674	—	1,244	—
1989	2,654	2,049	2,205	—	—	—	1,258	—
1990	2,185	2,142	1,983	1,871		1,298	1,215	1,282
1991	1,765	1,966	1,904	—	—	—	1,169	—
1992	1,786	2,003	1,881	—	—	—	1,158	—
1993	1,743	2,041	1,866	—	—	—	1,158	—
1994	1,669	2,060	1,835	—	—	—	1,150	—

Source: "Statistical Yearbook of Ministry of Agriculture, Forestry & Fisheries" by the Ministry of Agriculture, Forestry & Fisheries and Other datas.

Table 2. Shipment of Major Farm Machinery

Unit: Number

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1986	184,005	109,101	122,441	132,447	133,479	52,234	88,997	74,636
1988	213,941	90,261	84,531	144,705	108,958	39,950	66,618	59,666
1989	214,806	89,676	88,444	168,232	110,969	36,789	65,046	58,614
1990	205,944	95,691	89,139	183,820	107,227	37,117	65,247	51,954
1991	197,919	88,860	83,351	173,482	105,549	36,269	59,485	52,347
1992	199,141	88,754	80,105	184,016	105,028	20,888	60,941	52,275
1993	169,946	82,472	79,798	194,902	100,251	22,622	57,102	51,055

Source: "Survey of Shipment of Agricultural Machinery" by the Ministry of Agr., Forestry & Fisheries.

2). This shows a tendency that rice transplanters, tractors and combines with higher-horsepower, are decreasing in number.

Recently more and more used farm machineries are distributed. The rate of used farm machinery in the total sales amount is as follows: riding tractor forms 39%; rice transplanter 31%; combine 34%.

Movement of Farm Machinery Industry

Autumn in 1993, we Japanese especially farmers never forget disaster which damaged crops all over the country. The disaster caused by cold weather in Hokkaido and Touhoku district and many typhoons in west Japan. Especially in Shikoku even drinking water run short. Everyone knows these conditions make a bad influence to farm machine production. Japan Farm Machinery Manufacturer's Association announced production of farm machine in 1993 amounted to ¥576.3 billion, it was 101.1% of the preceeding year. This figure betrayed almost person's expectation. Why we got a good record in spite of a record disaster, we could guess one reason. You know Japanese farm income 75% is non-agricultural payment, only 25% is agricultural payment. Farmers had enough money to buy machines in the disaster year. In addition to it, rice price of farmer was skyrocket. This stimulated the eagerness of rice production farmer. If this disaster was happened fifty years ago, there would be people who went starvation to death. But, present Japan is not old Japan. Japanese economic power can overcome agricultural disaster easily.

In December 1993 GATT Uruguai Round came to a settlement. In the long run, a lot of Japanese were against rice import Japan. But, shortage of rice made Japanese import rice. In November 1993 imported rice from Thailand landed Yokohama port. Japanese government decided fundamental changes on rice-distribution. This will influence agricultural production involving farm machines. Therefore, farm machine manufacturers have to ready for this change.

And we have a few very important problem. One is environmental problem, engine emission is the problem we must solve. The other is PL law. In Japan this law will be effective July 1995. At this stage, nobody except what will happen. But we must make measures for PL law at once.

Trend of Farm Machinery Production

In 1993 the amount of farm machinery production was ¥588.6 billionm which increased by 2.0% over the preceding year. However, it would be almost same figure of the previous year except working machines for cultivation and leveling.

Production of the major farm machinery is as follows:

Riding tractor 146 115 units increased by only 1.0% over the preceding year. Seeing by h.p., those under 20PS amounts to 59 097 units, 20 ~ 30PS 56 150 units, over 30PS 30 868 units. Those of higher horse power shows an increasing tendency, while the small power production is decreasing.

The production of walking tractor amounted to 225 564 units, which showed a decrease of 8.2% over the preceding year. Under 5PS was 140 595 units, over 5PS 84 969 units. The production of combine, which is next to riding tractor is 65 192 units. This is an decrease of 0.7% over the preceding year.

Followings are the production of other types of farm machinery: rice transplanter amounted to 84,980 units (a decrease of 5.5% over the preceding year); grain dryer 56 079 units (an increase of 8.2% over the preceding year); huller 41 664 units (a decrease of

Table 3. Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machinery total		Riding type tractor		Walking type tractor		Rice transplanter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1986	—	647,265	209,078	254,010	268,307	37,026	134,433	64,541	157,774	9,754	184,132	6,374	7,121	9,535
1988	—	549,854	172,761	209,278	276,684	37,644	81,022	43,554	181,805	9,851	161,763	5,999	8,696	9,958
1989	—	553,368	157,544	197,947	275,629	38,735	87,615	46,337	184,098	10,015	156,802	5,845	9,901	9,400
1990	—	585,561	115,939	198,557	269,027	38,248	91,141	52,462	220,528	12,339	149,789	5,575	9,565	9,514
1991	—	615,131	148,437	203,260	270,714	40,102	87,019	54,265	198,887	10,607	163,306	6,155	9,318	12,766
1992	—	575,986	145,948	195,189	245,675	35,917	80,540	50,760	181,475	7,826	162,040	6,548	9,923	14,884
1993	—	588,627	146,115	186,983	225,564	33,738	84,980	58,344	165,909	6,899	134,901	5,985	8,559	12,155
(1994)	—	595,000	153,200	196,800	215,500	31,100	89,800	68,400	143,400	6,500	115,500	5,300	5,900	7,500

Year	Grain reaper		Brush cutter		Power thresher		Grain combine		Rice husker		Dryer		Grain polisher	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1986	55,587	13,777	1,496,433	27,191	41,295	15,246	93,080	150,188	72,000	19,060	73,798	44,590	66,891	3,537
1988	41,204	9,313	1,546,010	26,160	24,811	8,900	64,412	117,132	49,866	13,137	58,097	37,649	58,982	2,932
1989	37,291	8,841	1,689,181	28,501	23,835	9,005	64,789	127,309	47,478	13,900	55,537	35,244	61,298	3,223
1990	42,502	11,110	1,601,652	25,798	22,634	9,118	68,993	138,396	60,004	18,332	59,269	39,990	58,500	4,871
1991	37,782	9,542	1,657,897	27,117	20,337	7,898	72,913	152,827	60,690	19,124	57,747	43,250	57,625	5,243
1992	30,511	7,753	1,890,427	28,994	12,656	4,838	65,673	143,335	50,208	15,292	51,821	38,236	45,182	4,274
1993	27,286	7,173	1,588,837	27,399	11,663	4,562	65,192	149,867	41,664	14,129	56,079	44,224	40,368	3,844
(1994)	21,300	5,300	1,485,800	28,100	11,400	4,400	62,200	151,200	41,500	14,600	62,700	50,000	49,000	5,000

Source: "Survey of Status of Machinery, Production" by the Ministry of Interntional Trade and Industry. Data by Japan Agr. Machinery Manufacturers' Assn. and Land Internal Combustion Engine Manufacturer's Assen.
Note: Data for 1994 are forecast by Farm Machinery Industrial Research Corp.

Table 4. Farm Equipment Distributor and Sales Value

Unit: Million yen

Year	No. of retailers (1)	Employes	Annual sales value (2)	Inventory	Square meters of shop m^2	Annual sales value (2)/(1)
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5
1991.6	9,480	45,705	1,158,924	170,104	984,700	122.2

Source: Ministry of International Trade and Industry

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (1992 Business Year)

Unit: Million yen

Business year	Total number of coops. surveyed	Purchase in this term	Of which purchased through affiliated organs	Amount of supply and handling
1986	4,194	351,484	275,591	383,023
1988	3,976	337,970	259,915	379,709
1989	3,717	308,833	237,383	340,989
1990	3,591	349,521	268,763	375,660
1991	3,466	343,138	261,107	381,326
1992	3,204	354,728	268,393	388,031

Source: "Statistics on Agricultural Cooperatives—1992 business

17.0% over the preceding year); binder 27 286 units (a decrease of 10.6% over the preceding year); thresher 11 663 units (a decrease of 7.8% over the preceding year); bush cleaner 1 588 837 units (a decrease of 16.0% over the preceding year) **(Table 3)**. In 1993, cold summer dameged agricultural products badly, the period of rice harvesting had bad weather, it increased the production of grain dryer.

Trend of Farm Machinery Market

In Japan distribution system for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperative Association. As of June 1991, the retail shops were recorded to about 9 480, the employees amounted to 46 000 persons, and the annual sales amounted to ¥1 015.9 billion **(Table 4)**.

According to the governmental survey by Ministry of Agriculture, Forestry and Fisheries, the total sales of farm machinery by agricultural Cooperative Association reached ¥381.3 billion (¥388.0 billion in 1992) **(Table 5)**.

Under the declining demand for farm machinery, the farm machinery distribution industry has begun to improve the working environment: aiming at dissolving the shortage of hands and the settlement of the employment. In addition, the industry is striving for expanding facilities and rationalizing the management.

Export and Import of Farm Machinery

Export

In 1993 the exports of farm machinery amounted to ¥124.5 billion, which showed an decrease of 13.5% over the preceding year. The ratio of the exports to the total production amounts to ¥575.8 billion ended in 21.6%.

Seeing by the shipments, each region has decreased, especially shipment to Europe and Asia decreased by 26%. The largest market U.S., export is ¥44.8 billion, it occupies 36% of total exports.

As for the types of farm machinery, tractor was chiefly exported: 74 016 units were exported in 1993 (the total production was 146 115 units). It

Table 6. Export of Farm Equipment 1993
Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1986		150,792		
1988		130,492		
1989		131,042		
1990		132,757		
1991		129,943		
1992		143,891		
1993		124,505	100.0	U.S.A., Korea, France
Power tiller	44,575	3,491	2.8	France, U.S.A.
Wheel tractor	74,016	52,497	42.2	U.S.A.
Power sprayer	37,210	1,340	1.1	Korea
Duster	10,907	368	0.3	Taiwan, Korea
Lawn mower	87,881	7,754	6.2	France, U.S.A.
Brush cutter	1,250,299	29,263	23.5	U.S.A., France, Korea
Mower	69,181	2,613	2.1	U.S.A., Korea
Combine	3,691	6,288	5.1	Korea, Taiwan
Blade, knife	—	1,866	1.5	U.S.A., Korea, Italy, Germany
Chain saw	192,050	3,990	3.2	France, U.S.A.
Other	—	15,035	12.0	

Source: Ministry of Finance. Totaled by Japan Farm Machinery Manufactuer's Assn.

Table 7. Import of Farm Equipment 1993.
Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exporters
1986		17,425		
1988		23,095		
1989		27,245		
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578	100.0	U.K., Germany, U.S.A.
Wheel tractor	4,026	11,671	45.6	U.K., Germany, France
Pest control machine	1,080,594	1,214	4.7	U.S.A., Taiwan
Lawn mower	25,415	2,167	8.5	U.S.A., Sweden, Germany
Mower	1,606	841	3.3	France, Netherlands, Denmark
Hay making machine	1,290	639	2.5	France, Netherlands, U.S.A.
Bayler	741	987	3.9	Germany, France, U.S.A.
Combine	94	1,280	5.0	Australia, Belgium, Germany
Chain saw	36,804	1,156	4.5	Germany, Sweden
Other	—	5,623	22.0	

Source: Ministry of Finance. Totaled by Japan Farm Machinery Manufactuer's Assn.

amounts to ¥52.5 billion. Seeing by horse power, those under 30PS amounted to 55 923 units, those from 30 to 50PS 15 589 units, those over 50PS 3 504 units.

Major farm machinery, next to tractor, is bush cleaner. The total exports were 1 250 000 units, ¥29.3 billion.

The exports of other farm machinery are as follows: walking tractor 54 923 units; lawn mower 87 881 units; grass mower 69 181 units; chain saw 192 050 units etc.

Import

In 1993 the imports of farm machinery amounted to ¥25.6 billion, which means a decrease of 0.8% over the preceding year.

Followings are the major imported farm machinery: tractors 4 026 units (those more than 70PS were 3 095 units of all the tractors); chainsaw were 36 804 units. Half of the tractors were imported from U.K.

Trend of Research and Experiment

The surroundings of Japanese agriculture are very hard, because of claims for opening the market for agricultural products by foreign countries, consumer's various favor, the increase of the aged and the females as farmers, being called for the contribution to solve the environmental problems.

That's why the structural and technical reforms in Japanese agriculture are requested urgely.

Researches are chiefly made for high performance, automatic and popularized farm machinery in order to reduce cost in the production of agricultural products. Electronics and mechatronics are positively adopted for their technology. It is expected that technology for farm mechanization will be applied to biotechnology.

In 1993, the law promoting agricultural mechanization was revised. "Urgent Development Program" which is promoting the machine has a weak demand, but has a strong needs, is going ahead.

Regarding tillage, tillage and ridge making are being studied to save the energy. The technology for leveling ground in large fields is also studied for practical use.

Regarding transplanting low land rice, the method of part-ridge rice transplanting is being developed.

In the field of vegetable farming, the method of plantnursing control, a robot for grafting and the all automatic transplanters for leaf-vegetables, are being studied. Sweet potato seeding transplanter is being improved.

Regarding fertilization and seeding, cultivation and seeding with one process, non-cultivating seeding of field crops and the method of precise one seed seeding... etc., and various studies are continuing.

Regarding orchard machinery, cable-sprayer guided by cable was developed.

Regarding harvesting, large multi-purpose combine and whole harvesting-type machine were developed.

Regarding transportation machine, multi-purpose transportation and working machine in field and small container for heavy vegetables in small field machine have been developing.

Regarding animal husbandry, it has begun to develop milking robot. For vinylhouse, it has also begun to develop temperature control apparatus with form memorized amalgam. ■■

Research Activities in BICS Engineering Department of Regional Environmental Science University of Osaka Prefecture

by
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University Overview

The University of Osaka Prefecture (UOP) is one of the leading local-government-financed universities in Japan. The UOP has an integrated urbanized campus (126 acre) in the heart of Sakai-city, a cosmopolitan community of more than 810 000 with an enrollment of over 5 300 undergraduate, graduate and research students. The UOP's over 1 000 faculty and administrative personnel provide students with scrupulous care in every way. The University was established under the name of Naniwa University in 1949. In 1955 it was renamed the University of Osaka Prefecture. Since the first degree in 1953, the UOP has continued to grow. There are now five undergraduate colleges including a College of Engineering, a College of Agriculture, a College of Economics, a College of Integrated Arts and Science, and a College of Social Welfare; five divisions of Graduate Studies. There are currently about 750 students in graduate programs. They come from virtually every prefecture in Japan and 15 foreign countries.

The UOP is ideally located, within a 30-minute drive of Osaka City (the second largest city in Japan) with many outdoor recreational opportunities, cultural attractions and historic interests nearby. While having all the advantages of a large Osaka metropolitan area, the UOP campus is in a quiet historic atmosphere immediately adjacent to a 1500 year old archaeological asset (the world largest burial mound).

Geography

The city of Sakai is situated in west central Osaka Prefecture. It has a total area of 136.77 km^2 which expands to the southeast, with Osaka Bay to the west and Osaka City to the north across the Yamato River. Sakai is fitted in the Japan's well-developed sophisticated hi-tech public transportation system that lets everybody move freely to every part of the nation. Its population about 810 000 is the second largest of the municipalities within the prefecture. It is the beautiful city blessed with a mild climate where historically refined culture and huge industries coexist. Since ancient times, foreign trade and cultural exchange with overseas countries have been active in Sakai. Sakai has been famous for its enterprising spirit, where its citizens willingly accept new things and has continued to develop its unique culture and industry. KUBOTA's agricultural machines have been manufactured at their Sakai plant since 1947. Sakai's urban agriculture produces fruits and vegetables for fresh market of which output is valued at over US$31 million annually. In addition to that, Sakai is the largest milk producing district in the prefecture, worth US$14 million.

College of Agriculture

The College of Agriculture

includes the broad range of agricultural science disciplines. The 160 faculty provide professional leadership in four departments (the Plant Science, the Regional Environmental Science, the Applied Biochemistry, and the Veterinary Science) and 2 affiliated institutions (Experimental Farm and Veterinary Teaching Hospital). **Table 1** indicates four departments with 41 laboratories. There are 978 students in 825 undergraduate, 123 master's and 30 doctoral programs. The goal is to prepare students to integrate their skills with experts in other aspects of science and technology in agriculture, life science, and environmental science.

Table 1. Departments and Laboratories in College of Agriculture

Department	Laboratory
Plant Science	Genetic and Plant Breeding, Ecophysiology for Crop Production, Pomology, Vegetable Crop Science, Postharvest Physiology and Quality Control, Ornamental Horticulture, Plant Pathology, Entomology
Regional Environmental Science	Atmospheric Environment, Environmental Control in Biology, Bioinstrumentation, Control and Systems Engineering, Environmental Development Engineering Irrigation and Environmental Engineering, Urban Landscape Planning and Design, Landscape Architecture and Conservation, Agro-Resource Management, Agricultural and Environmental Politics
Applied Biochemistry	Biophysical Chemistry, Applied Molecular Biology, Fermentation Chemistry, Nutrition Chemistry, Soil Science and Plant Nutrition, Bioorganic Chemistry, Natural Products Chemistry, Food Chemistry, Applied Microbiology
Veterinary Science	Veterinary Anatomy, Veterinary Physiology, Veterinary pharmacology, Veterinary Pathology, Veterinary Microbiology, Veterinary Public Health, Veterinary Internal Medicine, Veterinary Surgery, Veterinary Reproduction, Molecular Biology, Veterinary Immunology, Toxicology, Laboratory Animal Science, Veterinary Radiology, Veterinary Epidemiology

Department of Regional Environmental Science

In April 1994, the Department of Agricultural Engineering at the University of Osaka Prefecture changed its name to the Department of Regional Environmental Science and initiated a regional environmental science undergraduate curriculum. The Department has expanded its discipline by adding three laboratories including Landscape Architecture and Conservation, Agro-Resource Management, and Agricultural and Environmental Politics to the traditional agricultural engineering body. The expansion of the department is an attempt to meet the intellectual and social needs for the sustainable, ecological and environmentally conscious development of the nation and the world.

Students in the Regional Environmental Science major may select courses from the curriculum according to their interests and future goals. Although specialization is not required, the program allows students to select from four different courses: biological environmental engineering, regional environmental engineering, environmental design, or agricultural and environmental economics. In all fields of study general themes include energy, environmental quality, conservation of natural resources, and health and safety.

Graduate Studies in BICS Engineering

The Laboratory of Bioinstrumentation, Control and Systems Engineering (BICS Engineering) offers the most engineering oriented research opportunities among laboratories in the Department of Regional Environmental Science. BICS Engineering is the application of engineering principles to the production, processing and use of biological materials. The field integrates many traditional engineering disciplines, with special attention given to the interface between physical systems and biological systems. Our laboratory has a long history of success in researching and developing machine systems for fruit, vegetables, and field crops. Much of the equipment under development for biological systems utilize microprocessors that are activated by electronic sensors. Recent advances in electronic vision and computer technology have opened the research horizons for greater accuracy in process control, product sorting, and machine operation. Environmental concerns relate to all aspects of biological systems engineering research.

The BICS Engineering Laboratory is emphasizing the following research subjects: flexible automation and robotics for bioproduction systems, intelligent information processing application technologies for bioproduction systems, postharvest technologies and food processing, and solar energy utilization in bioproduction.

Principal Investigator's Research Interests

NOBUO HONAMI, Professor, PhD: Tractor engineering, automatic control systems, image analysis, biorobotics, bioinformation analysis, environmental control systems, vehicle automation, terramechanics, water quality management.

HARUHIKO MURASE, Associate Professor, PhD: Intelligent information processing, computational mechanics, biosystem modeling, computer simulations, plant factory, bioproduction in space, biorobotics, machine vision technology, environmental control systems.

HIROSHI TAKIGAWA, Assistant Professor: Sensor technology, electronic devices, postharvest engineering for biological materials, stochastic systems analysis, automatic control systems, software engineering, statistical analysis, agricultural machinery

YOSHIFUMI NISHIURA, Assistant Professor: Machine vision technology, biorobotics, automatic control systems, solar energy utilization, greenhouse technology, bioinstrumentation, phytotechnology.

Current Researches

Prof. Honami's current research centers on two areas: water quality and biorobotics. The eutrophication of water in relation to water quality is one of the major research targets in Japan's environmental problems. Some species of water bloom assimilates nitrogen, phosphate and potassium dissolved in eutrophicated water. This research is directed toward developing a useful system for purification of eutrophicated water utilizing water bloom and ultra sonic engineering based machine system for collecting a large mass of water bloom. **Figure 1** shows clots of water bloom filamentous fungus research on development of a new grafting method 'Plug-In Method' in cooperation with fine cutting technology for living plant tissue is a spin-off from his research on robotic system for grafting. The idea of 'Plug-In Method' can be recognized on **Fig. 2**.

Prof. Murase's current research interests in BICS engineering range from intelligent information

Fig. 1 Colts of water bloom.

Fig. 2 Grafted seedling by the plug-in method.

Fig. 3 SPACETRON.

Fig. 4 Vegetables grown in the SPACETRON.

processing including neural network applications for plant growth modeling and finite element neural network development for plant factory to bioproduction system in non earth gravity field. Prof. Murase has developed an

Fig. 5 Leaf color sensing device.

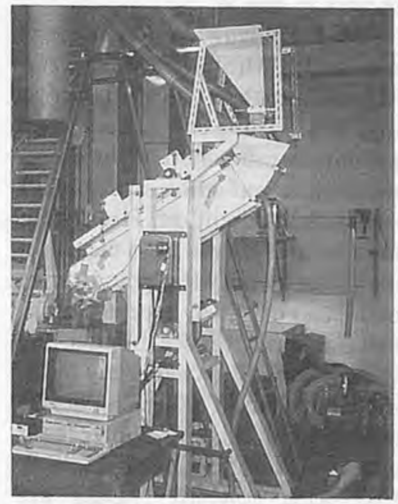

Fig. 6 Vibrating separator.

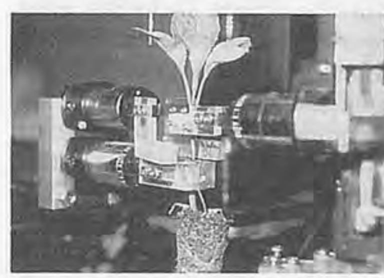

Fig. 7 End effecter of grafting robot.

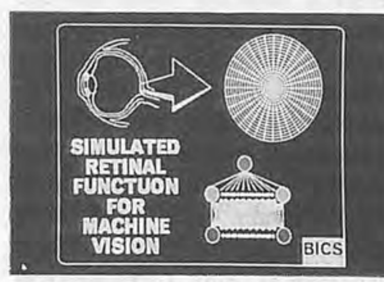

Fig. 8 Simulated retinal function.

innovative neuron training algorithm for layered neural networks using the Kalman filter. His training algorithm performs much better convergence on neuron training than any other conventional training algorithms such as back propagation and genetic algorithm. SPACETRON developed under his supervision is a special type of phytotron that can provide plants with different gravity as shown in **Fig. 3**. Vegetables grown hydroponically under 3 G in the SPACETRON are shown in **Fig. 4**.

Prof. Takigawa' main interests are in SSCM(Site Specific Crop Management) and grain processing. Prof. Takigawa is studying a primary sensing system for determining the leaf color of rice plant under field condition. His system that assures a real time measurement can identify leaf color of rice on a basis of widely accepted commercial leaf color scale under any weather conditions and any lighting conditions. The sensing device **(Fig. 5)** consists of 5 pieces of color sensor, operational amplifier and A/D converter. Data are processed by a microcomputer with a software including non-linear regression or neural network model. Prof. Takigawa has developed a vibrating separator for rice grain using the principle of segregation. The catch of this system is the ability to process very thick layer of grain unlike convectional gravity table **(Fig. 6)**.

Prof. Nishiura's current research interests focus on the development of grafting robot and machine vision technology using simulated retinal function. The research emphasis in biorobotics engineering has been to study grafting techniques which meet the necessary and satisfactory conditions in the view of plant histological and physiological standpoints in development of automatic production system for grafted seedlings. His research effort has made it possible to develop a grafting robot based on a principle of the innovative plug in method. **Figure 7** shows the end effecter that joins a scion and a stock. Development of intelligent robotic system for grafting requires high level machine vision technique. One of the most effective bioinstrumentation strategies is use of pictorial information obtainable from biological objects. He has been studying a solid state receptor arranged in polar coordinate system which serves as an artificial retina. **(Fig. 8)**.

Mr. Tomio Kobayashi is a full-time instructor and technician in courses related to BICS engineering Lab work. He is presently involved in the project of grafting robotic system and mainly responsible for fabrication of hardware system.

Books Published by BICS Staff Members Since 1990

1. Jyun-Gyakukaiseki Nyumon (Introduction to Inverse Analysis), In Japanese, 1990, Morikitashuppan Pub. Co., pp.234.
2. Shinban Nogyodorikigaku (Agricultural Prim Movers, New edition), In Japanese, 1991, Buneido Pub. Co., pp.274.
3. Faitotekunolozi Shokubutsu Seisan Kougaku (Phytotechnology), In Japanese, 1994, Asakurashoten Pub. Co., pp.199.
4. Kalman Neuro-Computing, In Japanese, 1994, Morikitashuppan Pub. Co., pp.175.

Graduate study

Graduate students working in BICS engineering can be truly involved in any of on-going research projects and trained in the most advanced research environment by experienced stuff members. Japanese MS student Mr. H. Nishijima is now conducting his responsible research work on shape recognition algorithm for a seedling needed for a machine vision system of grafting robot. Mr.Suroso from Indonesia is pursuing his MS degree. His research topic is the inverse analysis using neural network and finite element for heat transfer problem in relation to plant tissue culture technology. Mr. C.L.Kanali from Kenya has just started his PhD program. He is interested in neural network application in green-house and postharvest technology.

Our graduate program provides Master's degree and Doctoral degree. The graduate program is comprised of course work and research. Emphasis will be placed on individual research work evolved from a student's interest and an on-going faculty project. For Master's program, at least two years of enrollment is required. The period of enrollment, however, cannot exceed four years. For doctoral program, at least three years of enrollment is required. The period of enrollment, however, cannot exceed five years.

Scholarship for foreign students are mainly provided by the Ministry of Education (Monbusho). Those who are interested in Monbusho scholarship should contact the Japanese Embassy in their countries. In addition, our faculty may directly recommend candidates to the Ministry of Education. In this case, applicants who are interested in BICS engineering graduate study should contact Prof. N.Honami in advance at Dept. of Regional Environmental Science, College of Agriculture, University of Osaka Prefecture, 1-1, Gakuen, Sakai, 593, Japan. Applicants must be under 35 years of age. Admission to a master's program requires a bachelor's degree in agricultural engineering or equivalent field from a recognized university. A master's degree in agricultural engineering or equivalent field is required for admission to the doctoral program. ■■

Introduction of Agricultural Machinery Laboratory Department of Agricultural Engineering Tokyo University of Agriculture

by
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Introduction of the Faculty of Agriculture

Japan entered into modern era in 1867 and the Meiji Government adopted and promoted drastic modernization policy including the establishment of research and education systems throught the country. In the field of agriculture, which formed the basis for economic development during the period, a number of experimental stations and agricultural schools were founded throughout the country. The government schools mostly aimed at the training of personnel who would contribute to the national development as Government officers. Meantime, there was increasingly severe and urgent need for the training of former "samurai" and thier children to fit in the new era.

This lead Mr. Takeaki Enomoto, formerly a minister in the Tokugawa Shogunate Government and later also a minister in the new Meiji Government, to become the Chairman of Tokugawa Ikueikai Foundation established in 1885 in order to provide support for training of former Tokugawa official's children. The Tokugawa Ikueiko School was thus founded in 1891 with three specialized courses of two-year training; agriculture, commerce and general science. This agricultural course is the origin of the present Tokyo University of Agriculture. It became independent from the Tokugawa Ikueiko School in 1893 as Tokyo Agricultural School, for Enomoto placed extraordinary emphasis on agricultural development as the driving force in Japan's modernization. However, due to financial problems, the entire school was donated in 1896 to Dai Nippon Nokai, The Agricultural Society of Japan, which has been a national organization of leading farmers and agricultural scientists. With the management of Dai Nippon Nokai, the school entered into a new era of development under the leadership of Dr. Tokiyoshi Yokoi, one of the founders of modern agricultural science in Japan. In 1925, Dai Nippon Nokai established an educational foundation as an independent management corporation of the school, which was then renamed the Tokyo University of Agriculture (TUA). Dr. Tokiyoshi Yokoi resumed the position of President of the university, which became to be and remained in the following decades the only private agricultural university in Japan.

After the Second World War, the university moved and reestablished itself at the current Setagaya Campus in 1945. In 1949, the department of Agricultural Engineering was founded, which was followed to the Agricultural Civil Engineering founded in 1940. There are about 10 000 students studying in their respective departments and about 800 studens are studying in the Agricultural Engineering.

International Scientific Program

With the rapid economic growth in the 1960s, there also emerged a need for international cooperation. In 1966, TUA entered into a cooperative relationship with Michigan State University, USA. NODAI Research Institute was established in 1978, which for the following decade acted as the center for international scientific cooperative activities with Southeast Asian countries under the Core University System of the Japan Society for The Promotion of Science (JSPS). In 1989, execution of the core university system of JSPS Program was shifted to the newly established NODAI Center for International Programs (CIP). It works in close cooperation with 23 cooperative universities and 130 individual scientists at other universities in Japan, the Society for Agricultural Education Research Development Abroad (SAEDA) and the Japan International Cooperation Agency (JICA) as well as counterpart universities and Government institutions in Indonesia, Thailand, Philippines and Malaysia.

International Education Program

Internationalization in education was also rapidly promoted by further establishment of sister-college relations with Kasetsart University (Thailand), University of British Columbia (Canada), Beijing Agricultural University (China), National Chuing Hsing University (Taiwan) and Michigan State University as well. Wide-ranging exchange programs in education are now operated with these sister-colleges. At present, many types of student exchange program are available at TUA, which are mainly coordinated and implimented by CIP. CIP is also responsible for foreign students studying in TUA.

In 1994, more than 45 students came to our university and about the same visited to the sister-colleges.

Graduate School

Graduate school has also been strengthened in recent years in order to meet changing social needs and expectation on academic research. There are currently 11 major fields of specialization in the school: Agricultural Science, Agricultural Economics, Agricultural Chemistry, Forest Science, Animal Science, Food and Nutritional Science, Agricultural Engineering, Fermentation Science and Technology, International Agricultural Development, Landscape Architecture, and Bioregulation Studies, of which the first five courses offer the Master's and Doctorate Degree and the following five only the Master's degree at present. Bioregulation Studies offers only the Doctorate degree. By March 1994, a total of 145 students have been granted a Ph.D degree in this way. Although Agricultural Engineering offers now only the Master's degree, Doctorate degree course to Bioregulation Studies is opened to students. In addition, the Japanese education system allows for a special dissertation doctorial program, under which an established scientist need not go through the regular doctorate on the merit of submitted dissertation. By March 1994, a total of 1128 scientist from various countries had obtained their degree from this university.

Agricultural Machinery Laboratory

Agricultural Machinery Laboratory, TUA is one of following seven laboratories in the Department of Agricultural Engineering.

1) Irrigation and Drainage:
   Prof. Kiyotune Shirai
2) Land improvement:
   Prof. Toshio Sato
3) Land Reclamation and Improvement:
   Prof. Susumu Koide
4) Farm Construction:
   Prof. Kagetoshi Amano
   Prof. Yamaji Shirataki
5) Agriculture Machinery:
   Prof. Tadashi Kobayashi
6) Agricultural Products Processing Machinery:
   Prof. Shigeo Umeda
   Prof. Fusakazu Ai
7) Institution for Utilization of Scientific Technics, Research and Education:
   Prof. Ryousaku Kato
   Prof. Takafusa Sasaki

Total number of formal teaching stuffs in the department is 10 professors, 5 associate professors, 5 assistant professors and 5 research associates.

Present staffs are:

Professor:
Dr. Tadashi Kobayashi

Associate Professor:
Dr. Koji Tamaki

Assistant Professor:
Kiyoshi Tajima

4 master course graduate students, including a student from Korean, 12 students of 4th grade and 7 students of 3rd grade are now studying in the laboratory. Master thesis subject for these students are as follows:

Mr. Masashi Koizumi:
A Study on Image Recognition of Cubic Subject in the 3D Space by Computer Vision.

Mr. Park Euljin:
A study on the Measurement Systems for Simple Guidance of Agricultural Vehicle.

Mr. Teturo Takashima:
A Development of the Control system of GULLWING Robot using Laser Guidance system.

Mr. Masahiro Yatabe:
A study on the Control systems for Simple Guidance of Agricultural Vehicle.

The University's guiding principle in education is the practical application of science and technology in agriculture, ranging from production to marketing and consumption of agricultural products. The heavy emphasis on practical education can be seen from the mottos, "Ask to the rice about rice," and "Return the personnel

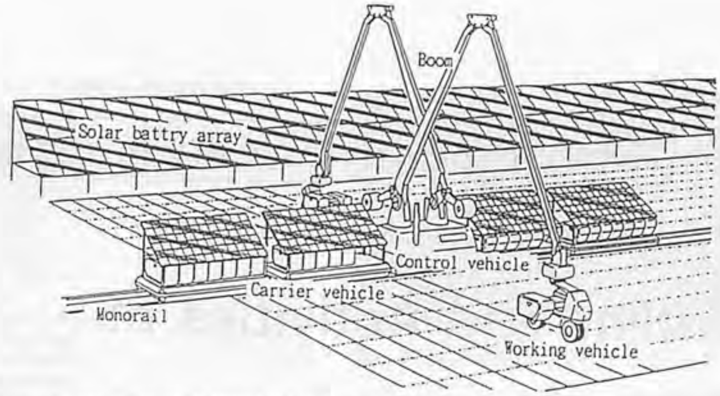

Image of an agricultural robot for field use

to the community." Not only the study of advanced theories but also the experiment and practice of theories and techniques in laboratory and field training constitute majour parts of this university's education, In particular, the *kenkyushitu* (laboratory) system is a unique way of education in this university. All the students, according to their own of academic specialization, must belong to a *kenkyushitu*, which functions as a unit of education and research as well as a society where students cultivate their character under continued guidance of a group of faculty members. It is hoped that students acquire not only the professional knowledge and skill but also well balanced personality necessary to contribute as leaders in the progress of agriculture and related industries.

Agricultural laboratory of course relates to the fields of farm power and field equipments working in the farm. Recently, in order to meet a need for high technology, the activities of the laboratory mainly are focused on robotic field.

Agricultural Robot

For future agricultural production, it will be easily affirmed that energy and environmental problems will become the major causes of triggering future change in this field. In this future situation, the demands for agricultural machinery powered by solar energy will grow more. But, working with agricultural machinery powered by solar energy in the farm will mean solving the problems of how to work them with less energy, though present tendencies of development in agricultural tractors are moving toward higher power. In the Agricultural Machinery Laboratory, some technological themes necessary for developing solar powered agricultural robot is examined and prototype model is developing.

From the viewpoint of designing the machine, it can be concluded that the power needed for the machine should be as low as possible. Key technologies of development for agricultural machinery workable with lower power energy such like solar light are as follows;

1) Technology for making the weight of the machine lighter.
2) Technology for compensating working loss of efficiency.
3) Technology for cultivating methods with lower energy.
4) Technology for energy delivery systems.

Under these considerations, many studies such as design of the robot mechanism, control of the robot, cultivation system for the robot working on the farm and recognition of crop and soil state using machine vision are examining. These elements integrate totally to the agricultural robot in the future. An image of the robot and a scale model under development in the laboratory are shown in the picture.

Main Academic Papers

Tamaki, Tajima, Takashima, Kobayashi:
Concept and Development of Agricultural Robot for Field Use Fed by Solar Energy. XII C.I.G.R World Congress and AgEng'94 Conference on Agricultural Engineering. (Milano) N.94-E-027

Tajima, Tamaki, Kobayashi:
Measurement of the Properties of Granular Material by Tine-Sensor. Japanese Society of Agricultural Machinery Journal, 54(6), 13 ~ 19, 1992

Tamaki, Tajima, Watanabe, Yukumoto:
A Study of Evaluation of Plant Growth on the Basis of Picture Received by Still Picture Communication Systems. Japanese Society of Environment Control in Biology, 30(2), 87 ~ 91, 1992

Kobayashi, Tamaki, Tajima, Yoshimura, Kato:
A Study for Robot Application in Agriculture. Journal of Agricultural Science, Tokyo Nogyo Daigaku, 39(1), 80 ~ 87, 1990

Tamaki:
Studies on Measurement of Plant Weight and Optimal Control of Plant Growth. Japanese Society of Environment Control in Biology, 29(4), 179 ~ 184, 1991

■■

Outline and Activities of Shikoku National Agricultural Experiment Station

by
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Background and Research Objectives

The arable lands of the Shikoku District in Japan are located at various geographical and climatic conditions, i.e., flat land, hilly and mountainous areas, coastal regions and small islands. This condition has brought about the development of different types of agriculture based on specific locations. The average landholding of farmers in Shikoku is rather limited compared with other districts of the country. As a result, the district is characterized by a highly intensive agriculture with a multiplicity of land use.

The Shikoku National Agricultural Experiment Station (SNAES) has since been playing a leading role in developing agriculture in the district. It has two campuses in Zentsuji, Kagawa Prefecture: the Senyu campus and the Ohsayama campus. The former campus is home to four departments, namely; Research Planning and Coordination, Administration, Crop Breeding and Agro-Environmental Management. On the other hand, the latter campus houses the Department of Hilly Land Agriculture as it is situated on the slope of Mt. Ohsa.

The keynote of SNAES is helping establish a "Sustainable Agriculture in Harmony with Human Beings and Environment". As such, its activities are focused on basic research insofar as developing agriculture in the district is concerned. The current research objectives of SNAES are categorized into four major areas as follows: 1) studies for the development of agriculture in the entire region of Shikoku District; 2) technological development for advanced agriculture to render farming less back-breaking and at the same time conserving the environment; 3) improvement of overall productivity based on intensive multiple land use, particularly for paddy fields; and 4) technological development for the production and distribution of farm products with high quality.

Brief History and Organization

The SNAES started as the Shikoku Branch of Central Agricultural Experiment Station of Japan to assist in the reconstruction of agriculture in the Shikoku District in 1946 — soon after World War II. By 1950, the Shikoku Branch and Chugoku Branch were merged into the Chugoku-Shikoku National Agricultural Experiment Station wherein the Departments of Crop Science and Land Use Technology were added. Two years later, the SNAES became independent with the addition of the General Affairs Section, the mandate being to concentrate on the development of agriculture in the Shikoku district. The Departments of Administration and Research Coordination were added in 1957 and 1963, respectively.

The current organizational structure of SNAES is composed of five departments as follows: 1) Administration; 2) Research Planning and Coordination; 3) Hilly Land Agriculture; 4) Crop Breeding; and 5) Agro-Environmental Management (**Fig. 1**). Some 126 staff and personnel, including 65 science researchers, man the SNAES.

The Laboratory of Agricultural Machinery and Activities

As indicated earlier, the main objective of research activities of

Director General
- Dept. of Research Planning and Coordination
  - Planning Section
  - Research Coordination Section
  - Research Information Section
  - Library and Documentation Section
  - Field Management Section
  - Research Project Team
- Dept. of Administration
  - General Affairs Section
    - Ohsayama Office
  - Accounting Section
- Dept. of Hilly Land Agriculture
  - Lab. of Regional Planning
  - Lab. of Land Consolidation
  - Lab. of Farm Management
  - Lab. of Soil and Water Conservation
  - Lab. of Agricultural Machinery
  - Lab. of Fruit tree
  - Lab. of Grassland Farming
  - Field Management Section
- Dept. of Crop Breeding
  - Lab. of Plant Biotechnology
  - Lab. of Barley Breeding
  - Lab. of Crop Eco-Physiology
  - Lab. of Vegetable and Ornamental Plants
  - Lab. of Crop Resources
  - Lab. of Food Quality and Post Harvest
- Dept. of Agro-Environmental Management
  - Lab. of Plant Pathology
  - Lab. of Insect Pest Management
  - Lab. of Soil Ecology
  - Lab. of Agro-Meteorology

Fig. 1 Organization of SNAES.

SNAES is to develop and improve agricultural machineries for use in the hilly land with the aim in view of reducing labor requirement. Some of the recent developments pertain to the hillside tractor, monorail machineries and soil management technique, particularly the use of a vibrating subsoiler. In all of these developments, the safety and convenience of the farmer is given due consideration which is why the man-machine and man-operation relationships guide the techniques developed.

Some Technical Accomplishments

The Vibrating Subsoiler

This innovative machine **(Fig. 2)** has been designed and developed to cultivate hilly and slopelands as it loosens layers of topsoil that otherwise would not be useful in growing crops. The subsoiler has a speed of 0.62 m/s on 10° slopes and loosens soil layers at the rate of 8.4 kgf/cm^2 with soil hardness under 0-25 cm changes to 2.4 kgf/cm^2. In cultivating radish, yields and quality are improved and the pulling force are reduced.

The Primary Carrot Thinner

The special variety of carrot, particularly the ''Kintoki Ninjin'' requires 2 or 3 thinnings before it is harvested in order for the carrot to develop into slender size, hence fetch better price. And thinning is in a half-sitting posture done under the scorching heat of the summer sun — a chore that is punishing to the farmer. The Primary Carrot Thinner **(Fig. 3)** has developed to break through those heavy duties. The mechanism is that the thinning blades attached to chains drawing the ellipse locus make regular spaces in two rows. The truck of the thinner can be used to seed and fertilize. The machine that thins, seeds and fertilizes to carrot makes the carrot production comfortable.

The Pivot Turn Vehicle

This pivot turn vehicle **(Fig. 4)** was developed for slopeland farming or mowing that is safe even as it can turn around almost in any direction. It operates on the principle of a trunnion or an axis on which the machine pivots. It is a 4-wheel drive with a trunnion each on front and rear wheels. The vehicle's tread is 1.4 times longer than its wheel base. Steering is done with the use of a round handle that is easy to operate. It can turn at its side, make a pivot turn both sides in opposite directions and yet is stable operations of contour direction even on a 30° slope.

Fig. 2 Vibrating subsoiler.

Fig. 3 Primary carrot thinner.

Fig. 4 Pivot turn vehcle.

The New Concept Monorail System

Otherwise called the ''Tall Monorail'', this new innovation is automatic and robotic that transports loads on hillside farming that otherwise are carried by farmers on their shoulders or in their arms up and down hillsides. The vehicle **(Fig. 5)**, including the hydrostatic transmission (HST) is

Fig. 5 Driving vehicle of tall monorail.

Fig. 6 Automatic pest control apparatus.

Fig. 7 Fruit loading machine.

remote-controlled, can travel up and down with a maximum load capacity of 200 kg on maximum slope of 45° at 0-0.75 m/s and can be controlled as far away as 25 m. The monorails are set over treetops using struts of hedging. The monorail can be adapted to an automatic pest control apparatus (**Fig. 6**) or fruit loading machine (**Fig. 7**). The pest control apparatus is an automatic machine that can spray chemicals into fruit trees from both sides with air blast spray. On the other hand, the fruit loading machine is a bucket conveyor fitted on the truck vehicle on the monorail that puts fruits into the bucket that is automatically conveyed to a container on a waiting vehicle.

The Branch Road for Orchards

Most citrus orchards in Japan are located on well-drained slopes

Fig. 8 Paved branch road with coagulator.

Fig. 9 Walkin type pest control machine.

Fig. 10 Riding type pest control machine.

facing north for maximum sunlight. With these features in mind, SNAES developed a simple technique using a branch road and a spot spraying machine. The end view is to render spraying comfortable and to reduce labor requirements. The Branch Road (**Fig. 8**) is 80-100 cm wide and is developed for contour direction on every 1-2 rows of fruit trees. The road uses the orchard soil for mixing the coagulator and cement in paving the road that does away with the rolled compaction. The pest control machine (**Fig. 9**) is a crawl type, 2 020 mm long, 800 mm wide, 1 350 mm high and weighs 470 kg. In a 20° slope, the machine can work/cover 10a (0.10 ha) in 25 min or 33 min for the same area in 25° slope of terraced fields. It can apply 400-500 litre of spray and its deposit rate is 90%. A bigger machine of the riding

Fig. 11 Mounted type roll baler.

Fig. 12 Simple bale wrapper.

type is under development (**Fig. 10**).

The Compact Roll Baler

A new baler of forage crop has been developed with a view to savings both labor and costs for livestock raisers on a small scale field. The bales are rolled into 45 cm in diameter cylinder-shape pack that weighs about 35-50 kg. The baler is a mounted type machine that produces chopped materials top-filled from the forage harvester (**Fig. 11**). It can harvest and bale at 1.0 to 1.4 t/h. Attached to the machine is a simple bale wrapper (**Fig. 12**) that seals the bales for high quality silage.

Time Motion Studies

These studies concern analytical examination of ergonomic aspects of hillside farming in an effort to better understand the burden of farm work in slopelands. Six sample farmers of varying ages were analyzed in terms of measuring the heart beat index and oxygen intake in hand-carrying a 20-kg container on flat land. Preliminary result shows that there was a high correlation between the heart index beat and oxygen intake. ■■

Outline and Activities of National Grassland Research Institute

by
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Director
Department of Forage Production and Utilization
National Grassland Research Institute
768 Senbonmatsu, Nishinasuno
Nasu-gun, Tochigi 329-27, Japan

Objectives of the Institute and Main Research Activities

The National Grassland Research Institute (NGRI) is a governmental research center responsible for the implementation of basic and advanced research covering fields such as development, management, production and utilization of grassland and forage plants for promoting grassland farming based on the land resources and climatic conditions prevailing in Japan.

Main research activities are as follows:

1. Analysis and control of grassland ecosystems.
2. Development and management of grasslands adapted to the natural environment.
3. Breeding of forage plants.
4. Technology for the production of high yield and high quality forages and technology for the management of environment.
5. Processing, storage and evaluation of forages and technology for the improvement of animal productivity by forages.
6. Feeding and management of cattle under grazing condition.
7. Analysis of production systems on grassland farming and improvement of information researches.

Note: Alpine Region Branch; 375-1 Shiono, Miyota, kita-sakugun, Nagano, 389-02.

History of NGRI

The National Grassland Research Institute was established in 1970 as the central organization for pasture and forage crop research. It started with three departments and a branch. Until 1886, the institute was reogranized: Research Planning and Coordination Office, Grassland Planning Department, Ecology Department, Environment Department Forage Production and Utilization Department, Grazing Animal Production Department and Alpine Region Branch.

Organization

Figure 1 show the ovberall organization chart of the present National Grassland Research Institute. The number of total personnels of NGRI is 217. And number of researcher 105 personnels.

NGRI is located at Nisinasuno (about 150 km away, north of Tokyo) with an area of about 228 ha. The Alpine Region Branch with an area of 72 ha is situated about 150 km away, north-weat of Tokyo, and near Karuizawa.

Department of Forage Production and Utilization

This Department is in charge of research on the production and utilization of forage crops cultivated in grasslands and converted paddy fields. etc., and the development of unexploited roughage resources to promote animal husbandry based on improved land use.

The principal subjects are as follows;

1. Physiology and cultivation of forage plants and Mechanization of forage production. (Forage Production Engineering Lab.).
2. Processing, conservation,

- Director General
  - Research Planning and Coordination Office
    - Research Planning Section
    - Research Coordination Section
    - Research Information Officer
    - Library and Information Section
  - Department of Administration
    - General Affairs Section
    - Accounting Section
  - Department of Grassland Planning
    - Land Evaluation Lab.
    - Production and Conservation Lab.
    - Grassland Development Lab.
    - Field Management Section
    - Livestock Management Section
  - Department of Ecology
    - Plant Ecology Lab.
    - Animal Ecology Lab.
    - Soil Microbiology Lab.
    - Ecological System Lab.
  - Department of Plant Breeding
    - Pasture Plant Breeding Lab.
    - Corn and Sorghum Breeding Lab.
    - Genetic Resource Lab.
    - Biotechnology Lab.
    - Plant Chemistry Lab.
  - Department of Environment
    - Plant Pathology Lab.
    - Plant Insect Lab.
    - Soil Fertility Lab.
    - Plant Nutrition Lab.
  - Department of Forage Production and Utilization
    - **Forage Production Engineering Lab.***
    - Forage Production Physiology Lab.
    - **Forage Conservation Engineering Lab.***
    - Forage Conservation and Processing Lab.
    - Forage Evaluation Lab.
    - Dairy Cattle Feeding Lab.
  - Department of Grazing Animal Production
    - Pasture Management Lab.
    - Grazing Management Lab.
    - Animal Reproduction Lab.
    - Beef Cattle Feeding Lab.
    - Animal Hygiene Lab.
    - Livestock Insect Lab.
    - **Ranch Mechanization Lab.***
  - Alpine Region Branch
    - General Affairs Section
    - Grassland Management Lab.
    - Livestock Husbandry Lab.
    - Soil Management Lab.
    - **Farm Mechanization Lab.***
    - Field and Livestock Management Section

* Section of Research on agriculture machinery engineering & mechanization.

Fig. 1 Organization.

Fig. 2 National Grassland Research Institute scene.

Fig. 3 Development of round bale wagon.

Fig. 4 Development of a mixer which mixes continuously into silage to prepare TMR (Total mixed rations).

storage of forage crops and unexploited roughage resources for cattle feeding and Mechanization of these operations. (Forage Conservation Engineering Lab.).

3. Evaluation of forage characteristics in terms of animal production.

Forage production engineering laboratory

This laboratory is in charge of research on the field machinery or mechanization system. At present, inprovement of the harvesting system relating round baler, development of the minimum tillage machine for grassland renovation or for arable land and fundamental studies on the efficient, labour saving working systems about the computer controlled steering of a tractor are conducting.

Forage conservation engineering laboratory

Labour-saving and cost-reducing system for forage conservation, feeding and marketing are object of study in this laboratory. Improvement and development of instruments for forage conservation and feeding are studied on the basis of researches into physical properties of forage.

Department of Grazing Animal Production

The Department of Grazing Animal Production aims at the development of techniques for increasing animal production on pasture. It covers research fields encompassing pasture management, physiology and factors limiting production of grazing animals to improve rearing methods as well as ranch facilities and machinery.

The main research objectives are as follows:

1. Maintenance and improvement of pastures and development of pasture evaluation methods.
2. Nutrition of grazing animals for improvement of animal production efficiency from pasture.
3. Reproduction physiology for

improvement of reproductive efficiency of grazing animals.
4. Growth characteristics grazing animals and development of fattening systems by full utilization of grassland.
5. Mechanism of physiological disorders of grazing animals and development of methods for the control of infectious diseases of livestock.
6. Biology and ecology of livestock pests in relation to the development of methods of control.
7. Development of ranch facilities and machinery and improvement of techniques of animal waste treatment.

Ranch Mechanization Laboratory

The Laboratory of Ranch Mechanization aims at the development of ranch facilities and machinery for control grazing animal and improvement of techniques of animal waste treatment.

Main subjects involved in animal control are behavioural control in herds, automated estrus detection and automatic health control. Through this project, automatic measurement system of water and weight for grazing

Fig. 5 Automatic scale of drinking water and weight for grazing animal.

animal and automatic gate for pasture rotation were development in this study.

At the animal waste treatment, main subject is the development of aerotic treatment system in liquid manure.

Alpine Region Branch

The Alpine Region Branch is located on the footslope of Mt. Asama at around 1 100 m above sea level in Nagano Prefecture. The Branch is pursuing a development of grassland farming utilizing mountaneous sloped lands with special emphasis on the systematization of beef production technology based on the cattle grazing.

The main research subjects are as follows:

1. Improvement, management and efficient utilization of sloped grasslands.

Fig. 6 Radio control fertilizer spreading machine designed for use on sloping terrain. We can avoid dangerous work, or operating a fertilizer spreading machine on sloping grassland owing to this radio control machine.

2. Improvement of management and growth of grazing cattles.
3. Preservation of soil fertility and conservation of sloped grasslands.
4. Mechanization of farm operation on sloped grasslands. (Farm Mechanization Lab.)

Farm Mechanization Laboratory

This Laboratory is pursuing mechanization and a rationalization of the operation in grassland utilizing mountainous sloped lands.

The main research subjects are as follows:

1. Development of the operation in sloped grassland.
2. Development of automatic field operation in slopeland.
3. Improvement of operations on the cattle grazing. ■■

(Continued from page 26)

Graeme Ross Quick

Date of Birth: March 10, 1936
Nationality: Australian
Qualifications:
1972 Ph.D., double major: Mech. and Agric. Eng., Iowa State University
1970 MS in Agric. Eng., Iowa State University
1958 Bachelor in Mech. Eng., University of Melbourne
1956 Diploma of Mech. Eng., Gordon Institute of Technology

Current Position:
August 1988 to present—Head, Agric. Eng. Division, International Rice Research Institute (IRRI), at the research centre, Los Baños, Philippines (will retire from this position January 31, 1995, and currently on special leave in Australia to write book on rice harvesting, and other IRRI assignments).

Experience:
1981 - August 1988—Director of Agric. Eng., NSW Dept. of Agriculture, Sydney, Australia.
1976 - 1981—Principal Research Scientist, Commonwealth Scientific and Industrial Research Organization (CSIRO), Highett, Victoria, Australia.
1972 - 1976—Senior Staff Engineer, White Farm Equipment, Brantford, Ontario, Canada.
1971 - 1972—Editor, International Association on Mechanization of Field Experiments (IAMFE), Aas, Norway.■■

Main Products of Agricultural Machinery Manufacturers in Japan

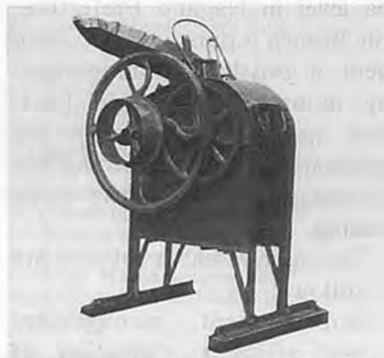
by
Shin-Norinsha Co., Ltd.
No. 7, 2-chome, Kanda Nishikicho
Chiyoda-ku, Tokyo 101, Japan

Introduced here are the main products of agricultural machinery manufacturers in Japan with a number of photographs.

The products are developed and improved for both foreign and domestic markets. For further information please refer to the manufacturers contained in the directory.

The ARIMITSU Cold Fogger Model LVH-15NCS with self-cleaning nozzle system to be operated by the built-in micro computor. Trouble free, more advanced, and efficient equipment for greenhouse pest-control.

BUNMEI Sugarcane Harvester Riding Type TK-5. Crop deviders equipped both sides raise fallen cane and give sure harvesting.



CHIKUMA Corn Sheller Type 3. Removes kernels from corn-cobs by a short time. Capacity: 750-1, 125kg/h, Power r'd: 1-2 PS, R.P.M.: 300-500, Size in mm: 1,015H x 575W x 1,010L, Weight: Net 90kg Gross 130kg, Shipping meas.: 18 cft.

DAISHIN Portable Generator SGB4000HX. Brushless generator; Non-fuse breaker; Quiet operation; AC Voltage: (50Hz); (60Hz) Max. Output: (50Hz) 3.6 kVA (60Hz) 4.5 kVA. Engine: Air-cooled, 4-cycle, gasoline 5.2 HP, 6.2 HP; Dry weight 65 kg.

ISEKI TF325 Tractor. Mounted with powerful and economical 25PS water cooled diesel engine. The tractor offers wide range of travelling speeds from approximately 1.2 km/h to 20 km/h, which offers broad operating application and safe road travelling.

ISEKI SF300 Mower. The 28 bhp

diesel engine gives you the power you need to deal with all your mowing tasks quickly, while its efficient use of fuel makes it economical as well. Cutting width: 1524mm, Cutting height: 30-120mm, Mower weight: 190kg.

ISEKI Multi-purpose Tiller KV700D. Four-cycle/direct injection/6PS engine allows heavy-duty operation at low speeds with ample power in reserve. Light, Compact, Easy to use and high performance.

KIORITZ Battery-powered U.L.V. Sprayer (Shoulder type) ESD-5. A compact and lightweight battery-powered U.L.V. Sprayer providing easy portability combined with high performance. It is designed for use in environmental hygiene control such as malaria prevention, etc. in addition to general-purpose applications. Operates on six 1.5 V batteries. A rechargeable battery pack can also be used.

KUBOTA Grand L Series Tractors. Built to handle a variety of agricultural applications, including field operations, heavy-duty front loader work. E-TVCS (Three Vortex Combustion System) Diesel Engine delivers more power and a high torque with cleaner emissions. In the GST (Glide Shift Transmission) models, the New GST features clutchless operation "shift-on-the-go" with faster response time and less power loss.

KUBOTA Combine Harvester SKY ROAD PRO 481-M. Easy-to operate, micro-computerized 4-line combine harvester that cuts down on time as well as crop. Equipped with many helpful mechanisms and a reliable water-cooled diesel engine. Max. output: 48PS/2700 rpm.

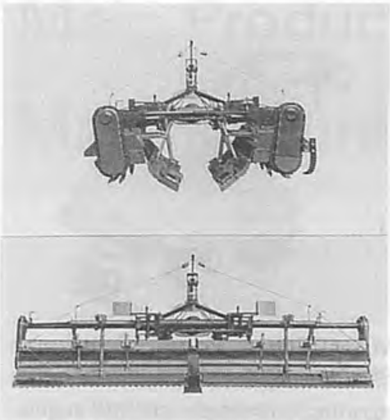
KUBOTA Power Tiller K120. With the Kubota power tiller, the preparation of the soil is easy and fast. It saves both time and energy, can work in any kind of field, wet or dry. 6 forward and 2 reverse speeds easily selected with only one shift lever.

MAMETORA Vegetable Transplanter TP-3V. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

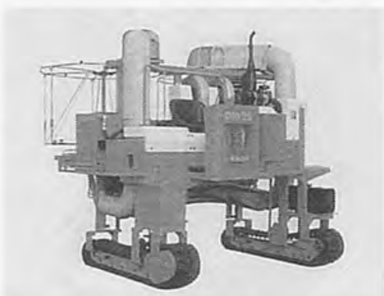
MAMETORA Power Cultivator SRV4V. Wide range use: cultivation to riding, Mounted with 7 PS engine.

MARUYAMA Portable Power Sprayers MS055D. Engine: Air-cooled, 2-cycle, output 22.6cc, Pump: Suction capacity 5.1ℓ/mm, max pressure 25kg/cm^2, Weight: 8.5kg.

MINORU 4-Row Onion Transplanter OP-41. Used for potted mature seedling. Seedling box can be directly put on the transplanter. Saving the labor and total cost. Measurement (mm): L-2720, W-1095, H-1150. Weight: 355 kg (body only). Engine output (PS/rpm): 2.7/3,600; max. 3.5/4,000. Wheels: drum type × 2.



NIPLO Wing Harrow HW-4102B folded by hydraulic power for transport. Working width: 417cm; Required tractor horsepower: over 50.

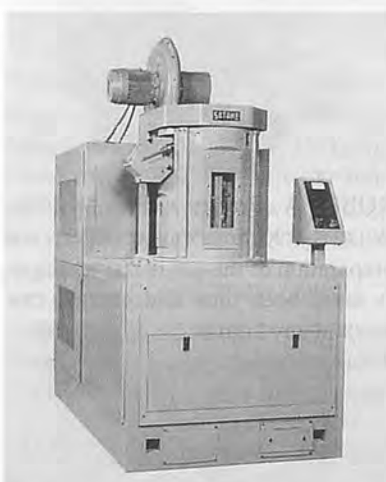


OCHIAI Riding Type Tea Picking Machine OM-25. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS.

OREC Power Cultivator AR700. Wide range use: Cultivation to riding. Mounted with 7 PS ~ 7.5 PS engine.

ROBIN Brush Cutter Model NBT415. 2 cylinder engine makes the operation easy and comfortable (low noise and vibration). Rotational speed of blade 4000-6000rpm.

SASAKI Fertilizer Spreader BF-300. The lever type action controls the amount of application with high accuracy. Application width: 10-12m. Hopper capacity: 300ℓ. Required tractor horsepower: 20-50PS.

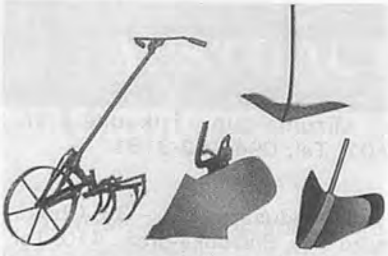


SATAKE New Rice Whiteness, Abrasive and Friction types, have high recovery, uniform & gentle milling, less installation space and high capacity. Model: VRM8A (Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/h brown rice.

SATAKE Color Sorters with their quality optics and high-grade electronics allow the operator to make efficient separator on the basis of color. Model: GS40AG/AK/AP, GS60AG/AK/AP, GS80AG/AK/AP and CS500B. Major Application: Rice, wheat, coffee, corn, sunflower, beans, spices, etc.

SHIZUOKA's Single Kernel Moisture Tester CTR-800E for rough rice, brown rice, wheat and barley.

STAR Mini-Roll Baler MRB 0810. Automatic pick-up, rolling and ejection. One bale every 30 seconds. Handy bale size (50cm in diameter and 70cm long). Required tractor horsepower: 18-30 HP.



SUKIGARA Hand Cultivator. Here ia a new HAND CULTIVATOR to replace conventional hand agricultural implements! With this model, you can work more easily and efficiently from an upright position no longer will you have to bend over to guide your cultivator.

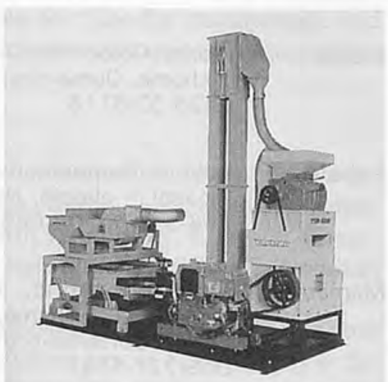
TACHIYAMA Roll Baler RB904. Working width: 900mm, picking up and baling long straw, cut straw, grass and etc. working efficiency: 20-40 a/hour. Required tractor horsepower: 30PS or over.

TIGER KAWASHIMA Rice Combi and Grader. Rice grading machine and automatic weighting and packaging.

WORLD Squeezer LP-5. The world's first continuous rice-bran vegetable seeds oil extraction equipment (SQUEEZERS). Type: LP-5 (ring system), Capacity: 8kg/h (Rice bran 5), Residual oil: 15% (Rice bran 10%), Power required: 0.4kW, Net weight: 90kg, Cylinder pressure: 5ton, Size in m: 1W × 0.5L × 1.2H.

YAMAMOTO Rice Whitener Ricepal Series Model VP31T. High recovery rate. Immatured rice can be milled. No remaining rice in the machine. Easy-to-change milling screen. Durable construction. Milling system: vertical type single pass, Size (H × W × L): 850 × 330 × 450mm, Weight: 24kg, Power required: 0.3kW, Electric mains: single phase 100V (50/60Hz), Capacity: 30kg/h, Rpm: 1440/1730, Hopper holding capacity: 15kg, Safety device: Circuit protection.

YANMAR Diesel Tractor US Series. 5 models: 20ps, 25ps, 30ps, 35ps, 40ps. Compact, quiet and vibration-reduced diesel engines are mounted at the heart of these US series tractors. Engine: vertical, 4-cycle, water-cooled. Transmission: gear shifting. F8 × R2 or F9 × R3 Drive system. 4-wheel drive.



YANMAR New Mill Mate YM650U. Cleaner + Huller & Polisher + Engine. Input cap: 800kg/h, Engine 23ps. This machine is a complete direct-through rice mill consisting of a hulling section, winnower and polishing section.

DIRECTORY

Arimitsu	Arimitsu Industrial Co., Ltd.—7-4, 1-chome, Fukae-kita, Higashinari-ku, Osaka, 537. Tel. 06-973-2010
Bunmei	Bunmei Noki Co., Ltd.—11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890. Tel. 0992-54-5121
Chikuma	Chikuma Farm Machinery Mfg. Co., Ltd.—356, Yoshikawa-koya, Matsumoto-city, Nagano-pref., 399. Tel. 0263-58-2055
Daishin	Daishin Co., Ltd.—3-23-1, Yoyasu-cho, Ogaki-city, 503. Tel. 0584-75-5011
Iseki	Iseki & Co., Ltd.—3-14, Nishi-Nippori, 5-chome, Arakawa-ku, Tokyo, 116. Tel. 03-5604-7600
Kioritz	Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo, 198. Tel. 0428-32-6118
Kubota	Kubota Corporation—2-47, Shikitsu-Higashi, 1-chome, Naniwa-ku, Osaka, 556-91. Tel. 06-648-2434
Mametora	Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363. Tel. 048-771-1181
Maruyama	Maruyama Mfg. Co., Inc.—4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo, 101. Tel. 03-3252-2281
Minoru	Minoru Industrial Co., Ltd.—447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama-pref., 709-08. Tel. 08695-5-1122
Niplo	Matsuyama Plow Mfg. Co., Ltd.—2949, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref., 386-04. Tel. 0268-35-0300
Ochiai	Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439. Tel. 0537-36-2161
Orec	Orec Co., Ltd.—23-4, Jyojima, Jyojima-cho, Mizuma-gun, Fukuoka-pref., 830-02. Tel. 0942-62-3161
Robin	Fuji Robin Industries Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410. Tel. 0559-63-1111
Sasaki	Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomori-pref., 034. Tel. 0176-22-3111
Satake	Satake Corp.—Ueno 1-19-10, Taito-ku, Tokyo, 110. Tel. 03-3835-3111
Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437. Tel. 0538-42-3114
Star	Star Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066. Tel. 0123-26-1123
Sukigara	Sukigara Agricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444. Tel. 0564-31-2107
Tachiyama	Tachiyama Co., Ltd.—1, 4-chome Takenouchi, Hiwada-machi, Koriyama-city, Fukushima-pref., 963-05. Tel. 0249-58-2331
Tiger	Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 349-13. Tel. 0282-62-3001
World	World Seiken Co., Ltd.—11-1, Yamazaki Ohiro, Tsuruoka-city, Yamagata-pref., 997. Tel. 0235-35-2555
Yamamoto	Yamamoto Co., Ltd.—404, Oinomori, Tendo, Tendo-city, Yamagata-pref., 994. Tel. 0236-53-3411
Yanmar	Yanmar Agricultural Equipment Co., Ltd.—1-32, Chaya-machi, Kita-ku, Osaka-city, 530. Tel. 06-376-6336 ■■

ABSTRACTS

The ABSTRACT pages is to introduce the abstracts of the article which cannot be published in whole contents owing to the limited publication space and so many contributions to AMA. The readers who wish to know the contents of the article more in detail are kindly requested to contact the authors.

075

Analysis and Economic Evaluation of Pigeonpea Grain Drying in Traditional Dal Mills: Phirke, P.S., Research Engineer, P.H.T. Schme; Kharche, D.S., Assoc. Professor; Sarode, P.W., M. Tech. Student, respectively, College of Agric. Engin. and Technology, Punjabrao Krishi Vidyapeeth, Akola Krishinagar 444 104, India.

A case study was undertaken for two dal mills of different capacities (2.5 and 0.8 tph), with a view to assessing the possibility of the introduction of mechanical dryer in place of the traditional sundrying as followed presently. The flow process chart, flow diagram and plant layout were developed from the observations, in order to study the time, motion and energy inputs with respect to all the operations performed. The study shows that there was a reduction in labour input by 20.5 and 8.38 man-h, total time of process by 118.2 and 105.9 h and the movement of product by 133 and 12 m, respectively, for Mill 1 and Mill 2. The energy input slightly increased which had no pronounced effect on the operation cost. The respective total cost of production of one ton grain decreased from Rs. 97.34 to Rs. 85.96 and from Rs. 105.06 to Rs. 94.75.

081

Prediction of Traction Potential of Wheel Tractors by Cone Penetrometer Method: Baloch, J.M., Assist. Professor; Leghari, N.A., Assoc. Professor; Rajper, A.G., Lecturer; Kartio, M.A., Assist. Professor; Brohi, Alimuddin, Assist. Professor, respectively, Faculty of Agric. Engin., Sindh Agriculture University, Tandojam, Pakistan.

The study of traction potential of wheel tractors was conducted on Latif Experimental Farm, Sindh Agriculture University, Tandojam during 1990. Three tractors (Ford 4600, Ford 6610 and Fiat 640) each with moldboard plough were used. The cone penetrometer method was used to predict the traction potential of the tractors. The cone penetrometer results were in good agreement with past research.

082

Field Data: A Tool for Farm Machinery Management in Nigeria: Nwandikom, G.I., Agric. Engin. Dept., Federal University of Technology, Owerri, Nigeria.

The use of machines and implements in agricultural operations has been recognized as a way of improving agricultural productivity and rural life. But the issue of efficient management of the machines is not yet fully addressed, hence, most of the available machines do not pay off economically before they completely breakdown.

Lack of spare parts and such others have been advanced as reasons for the poor management programme, but this paper suggests judicious collection, analysis and the use of machinery field data as a simple complementry approach to efficient and profitable management of the machines. A reliable machinery log book will among other things, promptly point out the time for maintenance and provide information for economic evaluation of the machines.

095

Scope of Mechanization on Small and Marginal Farms of India: Singh, T.P., Assist. Professor, Dept. of Farm Machinery & Power Engg., G B P U A & T, Pantnagar - 263 145 (Nainital) U.P. India.

India is an agriculture-based country. About 70% of the population (gross 800 million) is dependent on agriculture. The land area under cultivation is about 143 million ha of which 70% area is un-irrigated. The total food grain production in 1988-89 was 172 million t. According to 1980-81 agricultural census the percentage of marginal (less than 1 ha) and small (1-2 ha) holdings are 56.0 and 18.0%, respectively. These farmers are still using traditional farming equipment which are not appropriate for increasing productivity. For mechanizing farming of such communities, matching equipment must be made available which would suit their farming structure. Since the size of farm available with these farmers is limited to about 2 ha, the use of tractor or self-propelled machineries will be difficult as well as uneconomical. The animal and human power will remain to be the important source of farm power on these farms. Therefore, the machinery developed should match the power available. There is a great scope for mechanizing small and marginal farming by introducing new implements or making improvement in existing implements, introduction of selective farming, adopting more than one cropping practices and also through Government policies to increase labour productivity on these farms.

188

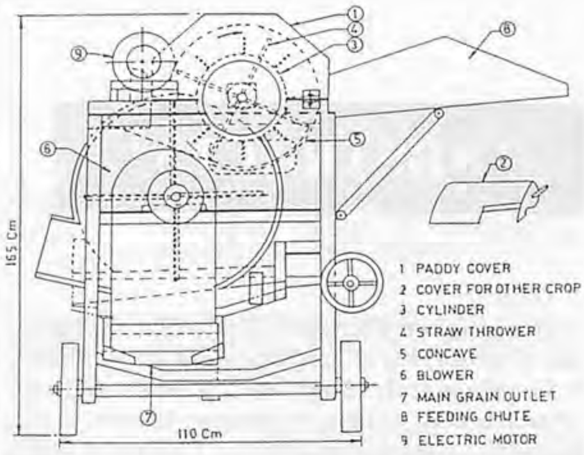
Balanced Soil Inputs for Increased Agricultural Production: Iqbal, M., Asst. Professor, Dept. of Farm Machinery and Power; Sabir, M.S., Assoc. Professor, Dept. of Farm Machinery and Power; Younis, M., Lecturer, Dept. of Farm Machinery and Power; Khaliq, Abdul, Lecturer, Dept. of Irrigation and Drainage; Azeemi, Sajid, Graduate Student, Dept. of Irrigation and Drainage, respectively, University of Agriculture, Faisalabad, Pakistan.

This paper focuses on the extent of various soil inputs for the increase of agricultural production. Great efforts have been made in the past to improve chemical, biological and hydrological inputs. The annual growth rate in the use of fertilizers has decreased from 31.2 to 8.8% for the corresponding years from 1965-70 to 1980-87 due to gradual increase in their prices. Over all, fertilizer use is expected to grow by about 6% per annum up to the year 2000. Nevertheless, the use of proper quantities of fertilizers and selection of proper time for plant protection measures is uncommon among the farmers. The distribution of the improved seed for all the crops have been increased from 48.42 to 75.22 thousand t for 1977 to 1986, respectively. Due to OFWM programme, about 53% water losses in water courses are saved at farm level but not much has been done to improve the conveyance efficiency in irrigation canals. In order to achieve the required crop production level, water availability must increase 1.0% per annum.

253

Field Evaluation of FIM-CIAE Multicrop Thresher for Oilseed Crops: Prasad, J.; Majumdar, K.L.; Scientist, Selection Grade (Farm Machinery and Power) AICRP on Farm Implements and Machinery, Central Institute of Agric. Eng., Nabi Bagh, Berasia Road, Bhopal, Madhya Pradesh-462 018, India., respectively.

A multi-crop thresher (**Figures**) was designed and developed at Bhopal under the All India Coordinated Research Project on Farm Implements and Machinery. The performance of the thresher was evaluated for threshing sunflower, rapeseed-mustard, linseed and safflower crops. The sunflower crop was threshed after feeding only the flowerheads while the other crops were threshed after feeding the whole plant. The performance of FIM-CIAE multicrop thresher was satisfactory in threshing the four oilseed crops. The output capacity of the thresher with sunflower, rapeseed-mustard, linseed and safflower crop was 172 kg/h, 82 kg/h, 164 kg/h and 73 kg/h, respectively. The hourly cost of operation was Rs. 20.87, and the costs of operation per tonne of threshed grain was Rs. 121.34, Rs. 254.51, Rs. 127.26 and Rs. 285.89 in case of sunflower, rapeseed-mustard, linseed and safflower crop, respectively.



256

Trends of Food Production, Procurement and Storage Facilities Bangladesh Experience: Miah, Md. A. Kaddus, Senior Scientific Officer, Farm Machinery & Postharvest Tech. Div.; Islam, Md. Nurul, PSO and Head Incharge, Irrigation & Water Management Div., respectively, BRRI, Joydebpur, Gazipur.

Food grain productions of Bangladesh had increased markedly by 17.54% i.e. from 16.08 million metric ton (mt) in 1986 to 19.5 in the year 1990. The total external and internal procurement of the country ranged from 1.5 mt to 3.3 mt.

About 85% of total storage of the country is covered by the farmer, trader and millers. Only 15% of the same is operated by the Directorate of Food. It was reported that the total storage loss of grain in different traditional structures was significantly higher. The total storage capacity of the Directorate of Food was 1.9 mt. However, with the increased volume of food crop production, the grain procurement of the country had increased but the total storage capacity of the Government had not increased accordingly to store the procured quantity. ■■

Asia-Pacific Regional Seminar on Technology for Utilization of Rice Husks and Other Agri-Waste

March 28-31, 1995
Beijing, P.R. China

Rice is the main crop in the countries in Asia and the pacific. The Sixth Meeting of UNESCO Regional Network For Appropriate Technology for Rural Development in Southeast Asia and the Pacific (ATNET) suggested the technology for utilization of rice husks as a priority of the ATNET activities for 1991-1993 and its Seventh Meeting approved to hold regional seminar in China.

Objectives

(1) To exchange information and experience in research, development, manufacture, operation and popularization of technology and equipment for utilization of rice husks and other agri-waste.

(2) To promote development of technology and equipment for utilization of rice husks and other agriwastes.

(3) To strengthen the links and cooperation between research institutes, universities, government departments, non-government agencies and manufacturers in the region and outside region.

International Workshop on Control Applications in Post Harvest and Processing Technology

June 1 and 2 1995
Ostend - Belgium

The scope of the workshop is to give the state of the art and application of control methods in storage and processes of agricultural and horticultural products.

The different focal points of the workshop are:

- Optimal control
- Measurement of crop produce responses for quality enhancement during storage or processing.
- Identification of control structures based on plant responses
- Intelligent, crop based decesion criteria
- Effect of product variablity on control strategy
- Compartments and instruments for controls in processing and storage
- Artificial intelligence application in post harvest technology
- System engineering in post harvest, storage and processing technology
- Main machine interaction in post harvest technology
- Economic and management evaluation of advanced of control systems in post harvest systems
- Social effects of automatic control in storage and processing

Contact: CAPPT'95, c/o BIRA, Desguinlei 214, B-2018 Antwerp, Belgium. Tel: 32-3-216 0996, Fax: 32-3-216 0689.

EXPO 95

July 30-August 1, 1995
Louisville, KY, USA

The dates set for the next International Lawn, Garden & Power Equipment Expo (EXPO 95) are July 30-August 1, 1995, in Louisville at the Kentucky Exposition Center. Contracts for exhibit space are being returned daily, and EXPO planners anticipate that the 1995 show will be the best ever for this international marketplace.

EXPO 94 was the most successful so far — with 581 display stands and 28 000 participants from 55 countries Twenty-nine manufacturers from countries outside the U.S. exhibited their products. Products from Italy, New Zealand, Germany, Canada, Japan, Taiwan, Australia, Ireland, Sweden and the United States drew interest from the international audience of dealers, distributors, grounds maintenance professionals, and retailers.

Details about exhibiting are available now. Visitor brochures will be ready in February. Pre-registration for the show is free; on-site registration is US$20. For information, contact Sellers Expositions, 550 South Fourth Avenue, Suite 200, Louisville, KY 40202, call 502-562-1962 or fax 502-562-1970.

Postharvest Horticulture ASIA 95 and Agriculture ASIA 95

August 23-26 1995
Philippine Trade Training Center, Manila, Philippines

The first Philippines International Exhibition and Conference on Postharvest Technologies for Horticultural Produce and the International Agriculture Technology Exhibition.

Contact: HQ Link Philippines, Inc,. Unit B, 8th Floor, Cacho-Gonzalez Building, 101 Aguirre St., Legaspi Village, Makati, Manila, Philippines. Fax: (63-2) 815 3152.

International Conference of Agricultural and Biological Engineering

September 20-23 1995
University of Newcastle upon Tyne, UK

The conference is a celebration of Agricultural Engineering at the University of Newcastle upon Tyre. The aim of the conference is to address the issue of the future of Agricultural Engineering and the important contribution of Agricultural Engineers to development in the third world. Contribution are invited on any of the following topics:

- Biosystems and Ecological Engineering
- Biomaterials and Bioprocess En-

gineering
- Bioinstrumentation and Environmental Measurement
- Environmental Management
- Amenity Engineering
- Trends in Agrotechnology
- Education and training for Agricultural/Biological Engineers

Contact: Marion Turner, Conferences Secretary, Faculty of Agriculture and Biological Sciences, University of Newcastle, Newcastle upon Tyne, NE 17RU, UK.

Alejandro A. Valenzuela Nominated President of A.L.I.A.

Alejandro A. Valenzuela, dean, College of Agriculture, University of Concepción-Chille and co-operationg-editor of AMA, has been nominated as President of the recently created Latinamerican Society of Agricultural Engineering known in spanish as A.L.I.A. (Asociación Latinoamericana de Ingeniería Agricola).

The nomination ocurred at last meeting of the Latinoamerican Society, at the lst. Congress held at Chillán, under the invitation of our Faculty of Ag. Eng. at the Chillán-Campus of the University of Concepción.

New Director General for IRRI

The International Rice Research Institute has appointed Dr. George Rothdchild as its new Director General, effective from 1 march 1995.

He will succeed Dr. Klaus Lampe. Dr Rothschild, 58, an entmologist from Australia, is currently the director of the Australian Centre for International Agricultural Research (ACIAR). As ACIAR director, Dr. Rothschild has been closely involved with issues of food production and distribution in developing countries and his earlier work in rice research will also stand him in good stead in his new position.

Report of Election Results from ASAE

As nominees for ASAE office, ASAE announces the results of the 1995 annual election for which the balloting was closed on December 1. The ballots were counted by clerks on our staff. The winners are shown as follows:

President-elect: Allen R. Rider
Professional Vice President:
Lyle E. Stephens
Professional Directors-elect:
Education Robert J. Gustafson
Publications Gary D. Bubenzer
MMTM Anthony H. Kajewski
Technical Directors-elect:
Food & Process Engineering
David P. Bresnahan
Information & Electrical Technologies
Stephen W. Searcy
Soil and Water James R. Gilley
Membership Directors-elect:
District 1 Stanley A. Weeks
District 3 James L. Steele
International Yoshisuke Kishida

The Ninth International Conference on, Mechanization of Field Experiments was Held Successfully

The Ninth International Conference and Exhibition on Mechanization of Field Experiments was held at and organized by Beijing Agricultural Engineering University (BAEU) on Oct. 17-20, 1994. This conference was sponsored by The International Association on Mechanization of Field Experiments (IAMFE), the General National Seed Station of Ministry of Agriculture, P.R. China, the Chinese

The rostrum of IAMFE/CHINA '94 conference.

Mr. Egil Øyjord (left), Mr. Guo Peiyu (middle) discuss with the designer of Chinese plot drill.

Society of Agricultural Engineering, etc.. 130 representatives attended the conference, and several hundred people visited the machinery exhibition and demonstration. Besides representatives from China, there are also 30 people from 16 other countries, including Norway, Sweden, France, Hungary, British, U.S.A., Japan, Philippines, etc.. The German manufacturer Hans-Ulrich Hege and the Austria manufacturer Wintersteiger showed their series machinery and tools range from seeding to harvesting, and the detail materials about these machinery and tools were also sent here. The SELECTA of Holland, the Massey Ferguson of British and the Wilson of Finland also showed their machinery at the exhibition. Chinese Kelian Agricultural Machinery Factory demonstrated their five kinds of machinery and tools used in field plot operation. Shanxi Hydro-Machinery Factory, Beijing Changyang Agricultural Machinery Factory, BAEU, Hebei Agricultural University, etc. also brought their seed processing equipment and field plot operating machinery to the conference. More than 70 papers of a large range of content were delivered to the conference, and 68 papers were published in a 432-page Proceeding. The Proceedings consist of 7 sections, that is Basic and Methodical Questions, Theoretical Questions, Plot Drill and Planters, Harvesting of Cereals and Other Crops, Seed Processing, Instrumentation, Computer Technology and Simulation, Plot Preparation and Other Technology.

It was the first time that a international conference on mechanization of field experiments was held in China. Discussing and exchanging new academic ideas, displaying materials and graphs, demonstrating machinery, and consulting technology cooperation are the characteristics of this conference, the relevant unit paid a great attention on this conference. At the opening ceremony on Oct. 17, Two former deputy ministers of Ministry of Agriculture, P.R.China, and many important people presented and gave addresses, then some participants gave keynote speeches. The machinery and tools from China and abroad demonstrated in the field of BAEU on Oct. 18, which attracted the attention of conference representatives and visitors, and some teachers and students of BAEU also visited the exhibition.

During the 3-day conference from Oct. 17 to Oct. 19, 34 papers were spoken and discussed. Representatives exchanged their ideas and views both at the conference and at spare times, and the significance of mechanization of field plot operation was recognized better.

IAMFE has been established for 30 years. Since 1964, according to the aim of IAMFE, it did a lot of work on improving the mechanization level of seed breeding, promoting the connection between engineers and seed breeders from all over the world, etc.and has got a lot of achievements. But in Asia the progress step was relatively small. China began to introduce foreign machinery and manufacture the self-designed machinery in small batch in 1978. From then on, the seed breeding speed and efficient have been improved to a great extent. But we didn't pay much attention on propagation, so the spread range of the machinery was limited. IAMFE/CHINA'94 conference was the first international conference of its kind in Asia. It was a important milestone for the development of seed breeding and processing industry of China. Two big companies—Hege and Wintersteiger—have signed intention contracts with Chinese manufactures. The technical and commercial consult between other manufacturers and users are still under way.

The IAMFE/CHINA'94 was a big success. The president of IAMFE, Mr.Egil Øyjord has done a lot for the success of the conference. At the IAMFE/CHINA'94 close ceremony and banquet for the 30th birthday of IAMFE on the evening of Oct. 19, the deputy minister Liu Cheng Guo of Ministry of Agriculture, P.R.China, the guests from Norwegian embassy and French embassy, the representatives of many countries and the committee of the conference all praised Mr. Øyjord for his work for IAMFE.

The Chinese Branch of IAMFE Preparatory Committee was also established during IAMFE/CHINA'94, and its committee member in charge is the vice president of BAEU—Mr. Guo Peiyu. It will follow the aim of IAMFE and work hard to develop high-yield, high-quality and effecient agriculture in P.R.China.

Swissmex expands economy knapsack sprayer line

Building on its recent successful introduction of a further 15-litre (4-gal.) no-frills knapsack model

Fig. After the success of its new 15-l SW-189 knapsack, Swissmex added a 20-l version.

dubbed "189", Mexico's sprayer maker Swissmex-Rapid S.A. is not wasting time to bring out a "289" as the 20-litre (5.3-gal.) version of the same well-accepted style. This hikes the firm's line of portable sprayers to 31 of which 18 are knapsacks, the rest compression units.

Apart from the larger tank, the new 289 uses the same components as the 189 model. Both offer the same advantages of easy pumping over a broad pressure range, low weight, especially rugged tropics-tested design (by using but a single check valve) and simple no-tools upkeep. All of the company's standard and optional accessories fit, as do commercially-available nozzle tips, formula filters etc. Service kits are offered that provide common replacement parts such as valve seals, piston sleeves, and even a re-sealable baggie for leftover parts.

For more information call:

Heinz Deppe
Deppe Ag-Tec Limited
P.O. Box MH-71014, Aldershot
Burlington, Ontario
L7T 4J8 - Canada
Fax 905/527-6599, Phone 905/527-6006

Jahrbuch Agratechnik-Yearbook Agricultural Engineering

(Germany)

edited by Dr. Ing. E.h.H.J. Matthies and Dr. agr. F. Meier

The seventh edition of Yearbook Agricultural Engineering has just been published in November 1994. It is in full translated into English with 21 chapters and round about 35 articles on 250 pages with many figures and tables.

The previous structure has been maintained - starting with situation of the agriculture and of the agricultural engineering industry. This is rounded off by reports relating to environmental engineering, bio-engineering, power engineering and municipal services engineering. The last chapter describes the situation in the new Federal states: development of education and research - university and not university based - and of agricultural engineering industry.

This book is available at the subscription price of 60. DM plus delivering fee from Dr. Fr. Meier, Redaktion Jahrbuch Agratechnik, Taunusstr 79, D 61440 Oberursel, Germany. Tel. 06171-72627, Fax. 06171 - 980205.

Biofertillzer in Agriculture and Forestry

(India)

edited by Dr. N.S. Subba Rao

In the third edition the scope of the book has been extended to Forestry and the title of the book has accordingly been changed to Biofertilizers in Agriculture and Forestry. The information for much needed nitrogen and phosphorus to the growing seedlings in the nursery stage has been increasingly realized, especially in afforestation practices aimed at recovering barren lands and sites spoiled by mining. In this sense this new edition adds a fresh dimension to microbial practices advocated to sustain plant growth through renewable sources of fertilizers.

The text provides scientific yet popular insight into crop and tree cultivation by organic inputs. It is invaluable for students, researchers, and administrators in the twin disciplines of agriculture and forestry.

Biofertilizer in Agriculture and Forestry is available from International Science Publisher, 2840 Broadway, New York, NY 10025, USA.

A Study on Conventional Farming Systems and Its Development — In the Case of Southeast Asia

(Japan)

edited by Dr. K. Ohara and Dr. V.M. Salokhe

This project report is review of the work carried under the research project 'A Study of Conventional Farming System and Its Development - In the Case of Southeast Asia'. The target countries were Laos, Vietnam and Thailand. This project was a collaborative work between the Mie University, Tsu; The Center for Southeast Asian Studies, Kyoto University, Kyoto; Kobe University, Kobe, Japan; Rangsit University and Asian Institute of Technology, Bangkok, Thailand.

A field study was conducted in Laos and Thailand during 1992 and in Mekong Delta and Laos in 1993.

This report contains the details of work carried out by the individual research workers in the study countries i.e. Laos, Vietnam and Thailand. The work of different researchers in particular country has been summarized in one chapter, however, the individual contributions are also included in the Part II of the report.

This report is available from Faculty of Bio-resources, Mie University, 1515, Kamihama-cho, Tsu 514, Japan.

Improving Animal Traction Technology

(Netherland)

edited by Paul Starkey, Emmanuel Mwenya and John Stares

This book derives from the first Animal Traction Network for Eastern and Southern Africa (ATNESA) workshop held in Lusaka, Zambia. It contains some 85 edited papers prepared by 105 authors from 30 countries. The text is supported by more than 400 illustrations, including 175 photographs.

Within the theme of Improving animal traction technology the papers focus on several important topics, including

- Profitability
- Animal management
- Tillage and Weeding
- Implement supply
- Gender issues
- Technology transfer
- Transport
- Diversifying operations

This book provides a wealth of ideas and experiences concerning animal traction in many countries and will be valuable to all people interested in this important field of agricultural development, especially those involved in training, extension, research, development, planning, gender issues and infrastructural support.

Obtaining copies of this book

Worldwide sales:

IT Publications, 103-105 Southampton Row, London WC1B 4HH, Unit-

ed Kingdom
Tel: +44-(0)171-436-9761
Fax: +44-(0)171-436-2013
ATNESA, c/o AGROTEC (UNDP-OPS) PO Box BW 540, Borrowdale, Harare, Zimbabwe
Tel: +263-4-860009
Fax: +263-4-860009
Tlx: 24668 UNDEV ZW

ACP-EU countries:
CTA, Postbus 380, 6700 AJ Wageningen, The Netherlands
Tel: +31-(0)0380-60400
Fax: +31-(0)8380-31052
Telex: 44 30169 CTA NL

Grain Quality Evaluation of World Rices

(Philippines)

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edited by Dr. B. O. Juliano and Dr. C. P. Villareal

This book contains 205 pages which dedicated work in this important research area that IRRI scientist-can routinely measure grain quality in prebreeding efforts serving national agricultural research systems. Grain Quality Evaluation of World rices is a much-needed data base of selected grain quality characteristics of milled rice from all countries producing more than 0.1% of the world's total. Quality characteristics and preferences are discussed by country, based on information obtained from national programs.

The apendix of analyses provides a ready reference and comparison among 2 679 milled rices and 244 wild rices analysed in the same laboratory under comparable conditions since 1963. This book expands the 1980 IRRI publication Quality characteristics of milled rice grown in different countries.

This book is available from Communication and Publicatons Services, IRRI, P.O. Box 933, Manila 1099, Philippines.

Rice In Latin America: Improvement, Management and Marketing

(Philippines)

The first book in 20 years to examine the role of rice in latin America and the Caribbean, Rice in Latin America: improvement, management and marketing was copublished by Centro Internacional de Agrcultura Tropical (CIAT) in Colombia and IRRI.

The book contains 12 papers and 50 poster summaries. The book interweaves four themes that are critical to rice production:

* Genetic Improvements: Modern rice varieties are already yielding at their full potential, but the world population keeps growing.
* Water management: Water is increasingly scarce and rice cultivation appears to be wasteful user.
* Red Rice: Many rice producing regions are being rapidly invaded by this noxious weed.
* Marketing: Latin American and caribbean countries are opening their markets and consequently changing political and economic policies.

This book is available from Communication and Publications Serivces, IRRI, P.O. Box 933, Manila 1099, Philippines.

Modern Rice Technology and Income Distribution in Asia

(Philippines)

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edited by Cristina C. David and Keijiro Otsuka

Two decades have passed since the introduction of modern rice varieties (MVs) and their accompanying technology in Asia. This volume looks at seven Asian countries with widely diverse production environments and agrarian and policy structures to determine to what extent the adoption of MVs only in the irrigated and the favorable rainfed-lowland areas has exacerbated inequalities in the distribution of income.

Refuting claims of Green Revolution critics, the contributors find that, when both direct and indirect effects of labor, land, and market adjustments are considered, differential adoption of MVs across environments did not significantly worsen income distribution. Instead, as MV adoption increased the demand for labor in the favorable areas, interregional migration from unfavorable areas took place, which mitigated potentially negative impacts by equalizing regional wages. Shifts to alternative crops or nonfarm employment in the unfavorable areas, as well as the enlargement of farm size, also contributed to the restoration of equity.

1994. 475 pages. 15.24 × 22.86 cm. Paperback. HDC, send orders to Lynne Rienner Publishers, Inc., 1800 30th Street, Suite 314, Boulder, Colorado 80301 USA; LDC, send orders to IRRI. US$12.00 plus airmail (US$9.50) or surface (US$2.00) postage.

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BACK ISSUES

(Vol. 25 No. 1, Winter 1994 ~)

NOTIFICATION

The editorial staff of AMA introducing some changes in editorial policy and requests contributors of articles for publication to observe following changes in order to improve communication process. These changes will play key role in facilitating the editorial process.

Articles for publication must contain one printed copy along with one copy on 3.5 inch floppy disk and black & white photographs for the articles.

Format Guidance

The floppy disk copy must contain the following format.

a. are written in english language;
b. are written in any of these format like DOS, Word for Dos, Word Perfect, Word Star, Word for Windows, Word for Macintosh and which should be written on the surface of the disc;
c. whole article must written in same format and style;
d. the pages on floppy disk must not be numbered;
e. the tables and figures titles must be numbered;
f. the data for the graphs must also be included.

The remaining Instructions to AMA Contributors are shown in the back side of AMA.

The editorial staff of AMA realize that some contributors still have difficulty to support these changes. In this case, please contact us. Please remember the articles in the new format will be given priority for publication.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo, Japan (Tel. 03/3291-5718, 3671 ~ 4)

INSTRUCTIONS TO AMA CONTRIBUTORS

The Editorial Staff of the AMA requests contributors of articles for publication to observe the following editorial policy and guidelines in order to improve communication and to facilitate the editorial process :

Criteria for Article Selection

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

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
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 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.
h. written on floppy disc.

Rejected/Accepted Articles

a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. "The AMA does not pay for articles published. However, the writers are given collectively 5 free copies (one copy air-mailed and 4 copies sent by surface/sea-mail) of the AMA issue wherein their articles are published. In addition, the main author is given an article on floppy disc with AMA true format. Co-authors can get a copy from main author.
d. Complimentary copies: Following the publishing, three successive issues are sent to the author(s).

Procedure

a. Articles for publication (original and one-copy) must be sent to AMA through the Co-operating Editor in the country where the article originates. (Please refer to the names and addresses of Co-operating Editors in any issue of the AMA). However, in the absence of any Co-operating Editor, the article may be sent directly to the AMA Chief Editor in Tokyo.
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.
c. The article must bear the writer(s) name, title/designation, office/organization, nationality and complete mailing address.

Format/Style Guidance

a. Article must be sent on 3.5 inch floppy disk with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows.....) along with one printed copy.
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e.g., "Figure 1. View of the Farm Buildings".
e. The data for the graph must also be included.
f. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
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.