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Special Issue:

The Farm Machinery Industry in Japan and Research Activities

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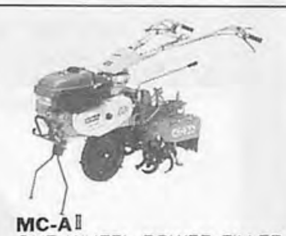

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This publication, published quarterly, has an objective to promote agricultural mechanization in developing countries. Its readers consist of so many people in various fields such as farmers, dealers, manufacturers, researchers, government officials, 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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EDITORIAL

Some Thoughts on Global Warming

A UN-sponsored conference on cutting greenhouse gas emissions was held last December in Kyoto, Japan in order to find solutions to one of the most formidable challenges facing mankind: global warming. The conference recognized that the rise in the earth's average temperature is caused by heat that is trapped within the atmosphere under a blanket of greenhouse gases such as carbon dioxide. However, the conferees found it quite difficult to come into a common agreement to set a legally binding numerical target for minimizing/eliminating greenhouse gas emissions considering that member nations vary by conditions under which they operate or are located.

One of the most serious problems created by global warming is whether the earth's ecological system could cope with the rise in surface temperature better than it could with the rise in sea-level temperature. The forest areas may fail to shift well in accordance with the climate changes, hence deforestation may ensue. Global warming, however, is expected to create new dry/arid areas to the detriment of agriculture in those areas even as global warming is said to have both positive and negative effects on agriculture. This then behooves all concerned scientists, technicians and policy makers to develop the required technology(ies) to reduce to a safe level greenhouse emissions through cooperative efforts such as in the design and performance of gasoline and diesel engines—mobile or stationary. Also a more widespread utilization of new recyclable energy or solar energy must come on stream.

One wonders how much more negative impact on the lives of mankind will global warming bring about when in the not-too-distant future the densely populated countries such as India and China could achieve the same economy and current ratio of cars per family that now prevail in advance counties such as the USA. It seems ironic that it is the advanced countries that need to cut down on energy consumption in order to mini-mize global warming.

As global warming also adversely affects agriculture in developing countries, the negative effects need to be fully understood through research so that solutions could be found to meet the problems head on. For example, agricultural engineering as a science and practice, must not only be harnessed to the fullest extent but also minimize greenhouse gas emission in performing timely farm operations. This is necessary for the production of adequate food availability to feed the ever increasing population utilizing limited resources such as land and irrigation water. It is for this reason that while we have the time, we must continue to develop efficient farm mechanization technologies in a common effort to help increase food production.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1998

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Development of Pneumatic Row-crop Planter in Pakistan

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Abstract

Prior to the development of a pneumatic planter by the Farm Machinery Institute (FMI), appropriate machines were not available in the local market for planting of oil seed crops. As a result there was no other option for farmers except to use the conventional drill machine for planting which affects the farmer in two ways: they have to apply higher seed rate and thinning operation has to be done which increases the production cost as well as it becomes a laborious job. With the introduction of the FMI pneumatic row-crop planter, the crucial problem of planting machine has been eliminated. With the help of this planter, the seed germination efficiency has increased many-fold and has reduced the seed rate. Now, thinning operation is not necessary as this planter places the seeds at required spacing.

The FMI developed planter was comprehensively tested for planting of cotton and sunflower crops. The overall performance of the planter was satisfactory for both crops. The economic benefits are also enormous such as planting cost of drill has been estimated at Rs. 900/ha while with planter is Rs. 359/ha, which is 60% less than the drill. Therefore, the farmers can achieve a benefit of Rs. 541/ha (Rs. 31.00 = one US$) by using FMI pneumatic row-crop planter.

Introduction

Oilseed crops, excluding cotton, are grown on an area of about 0.486 million ha in Pakistan. The average yield of these crops is 1.2 t/ha which is 60% less than those in developed countries. Pakistan's annual edible oil production is 3 115 000 t which is 25% of local consumption, hence the country is spending Rs. 25 billion for imports of oilseed. The import bill will rise further under the existing annual increase of 8% of edible oil consumption. Realizing the grave situation, the Government of Pakistan initiated, a National Oilseed Development Project (NODP) to increase edible oil production with financial assistance from the World Bank.

The FMI of the National Agricultural Research Center (NARC), was entrusted for the machinery development component of the NODP. After a series of meetings with the NODP scientists, oilseed crop production operations of planting, interculture, threshing, cleaning and grain drying were identified as priority areas for FMI to start with. An amount of Rs. 1.85 million was allocated for this project.

Proper row-to-row and intra-row spacings for sunflower (one of the important oilseed crops) plants is important for adequate aeration and soil nutrient uptake in order to achieve optimum crop yield. With the use of conventional planting drills it is not possible to maintain proper plant spacing. As a result farmers have to apply higher not only seed rate but also have to perform additional thinning operation. The FMI after thorough testing of available planting machinery identified pneumatic row-crop planter Model SP-520 (Gaspardo) as the suitable machine.

Necessary changes, such as removal of liquid/chemical applicator system; replacement of fertilizer metering mechanism, reduction in seed and fertilizer hopper sizes and a single speed gear box to provide adequate seed metering for sunflower, cotton and maize instead of multi-speed gear box were incorporated into the planter after which it was manufactured by a local manufacturer. There is also a provision for changing metering shaft speed of the gear box in this design by installing the desired set of sprockets. The locally manufactured unit was extensively tested for planting of cotton and sunflower crops during June 1992 and February 1993, respectively.

Machine Description

The FMI pneumatic row-crop planter is a four-row tractor rear mounted machine **(Fig. 1)**. It is driven by a tractor PTO at 540 rpm to operate its aspirator blower. Planting depth, row-to-row and inter-row spacings are adjustable. The metering mechanism of the planter uses air suction that is produced by the aspirator blower. The vacuum disc of each row is connected to the inlet chamber of the aspirator blower through a rubber tube. The seed metering disc has holes on its periphery. Air suction from the holes of the metering disc causeds the seed to stick against them. The drive to the seed disc is through ground the wheel at right side. The stuck seed is released from the rotating disc with the help of baffle cut which is situated near the opener. The absence of suction allows the seed to be dropped into the furrow. The planter's seed fall height is kept low in order to reduce the chances of non-uniform spacing which can occur due to the seed's bouncing if dropped from a high plane. The different seed discs with different hole sizes and numbers along their periphery can be used for different shapes of seeds and plant-to-plant spacings. The pneumatic metering system completely eliminates damage to the seed and its bridging which is essentially required to maintain accurate seed rate. The placement of fertilizer is simultaneously provided by the metering shaft driven from left side ground wheel.

Performance Tests

Field testing of the locally manufactured unit was conducted during June 1992, and February 1993 for the planting of cotton and sunflower crops, respectively. The testing for the cotton crop was conducted at the Central Cotton Research Institute (CCRI), Multan while the sunflower crop planting tests were performed in Daska and Sialkot areas. The overall and specific objectives of the tests were as follows:

Overall Objectives

1. To observe any mechanical breakdowns during field operation;
2. To observe the metering accuracy of the planter;
3. To observe the overall performance of planter; and
4. To recommend further design improvement.

Specific Objectives

1. Cotton crop:
   i. To determine the suitable hole size on seed disc for single seed placement of delinted cotton seed; and
   ii. To develop a seed disc with suitable hole sizes and orientation for the placement of 2-3 seeds/hill at 20-25 cm spacing interval.

Fig. 1 The FMI pneumatic row-crop planter in action.

2. Sunflower crop:
   i. To measure the field capacity, field efficiency and fuel consumption;
   ii. To measure the uniformity in plant to plant spacing; and
   iii. To determine the economics of use of the planter.

Material and Method

Cotton Crop Tests

The seed metering discs were fabricated in order to determine the suitable hole size and their suitable locations along the periphery of the seed discs **(Fig. 2)**. A new set of clod pusher and depth covering wheels were designed and manufactured to determine their suitability for varying soil and seed conditions. **Fig. 3** shows the configuration of clod pusher. Seeds of cotton variety CIM-70 were delinted and floater seeds were removed. The treated seeds were placed in seed hoppers and the planter was operated on plain surface by removing the furrow openers. Seed spacing data was randomly recorded for a 5-m length of each row from 5 locations. The number of double seeds were also recorded.

The average from seed spacing data, standard deviation and coefficient of variation were calculated to determine the uniformity of seed spacing.

Sunflower Crop Tests

The planting tests for the sunflower were conducted in fields prepared in Daska and Sialkot

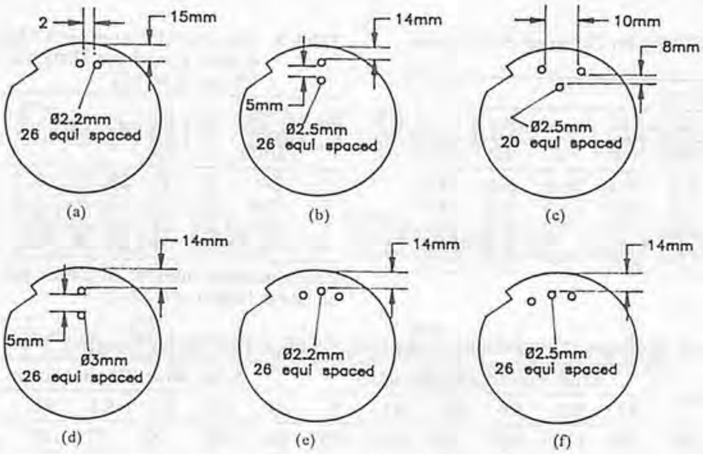

Fig. 2 Specification of seed metering plate developed for cotton.

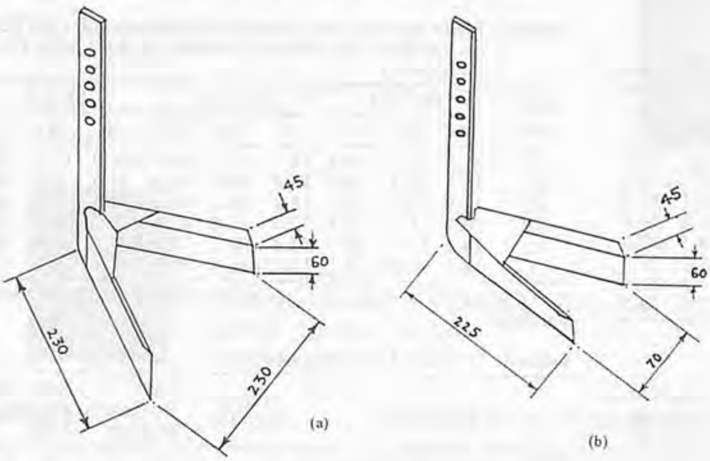

Fig. 3 Configuration of cold pusher; (a) original (b) modified.

area after the potato and rice crops. A total of 20 acres were planted with the machine and no major break down was observed except for a few adjustments. The planter was adjusted for 25 cm seed-to-seed spacing. The sunflower varieties SF-278, NK-265, and Contioil were planted. The number of established plants per 30 m of linear length were recorded in these two field conditions. The mean plant spacing, standard deviation and coefficient of variation were calculated to determine the uniformity of plant spacings.

Results and Discussions

Cotton

i) **Tables 1** and **2** show the average plant spacing, standard deviation, coefficient of variation and average number of plants per 5 m of linear length.

ii) Seed discs with 26 holes of 2.2 mm diameter was found better for single seed placement due to its low coefficient of variation.

iii) Seed disc of 26 equally spaced holes with 2.2 mm diameter hole sizes and 2 mm spacing along its periphery did not give any consistency in planting uniformity and, therefore, were not considered suitable.

iv) Seed disc with double holes of 5 mm vertical spacing and 3 mm diameter of each hole gave 52% double seeds/hill (i.e., 2-3 seeds/hill) as compared to 12% of double seeds/hill obtained using. **Table 3** showed the percentage of double seeds measured at random over a linear length of 15 m in a row.

Sunflower

i) The average number of plants recorded per 30 m of linear length for SF-278, NK-265 and Contioil under potato-sunflower rotation were 117, 108 and 103, respectively **(Table 4)**.

ii) The mean plant spacing of established plants for these varieties were 24.16, 27.0 and 26.6 cm, respectively **(Table 5)**. These averages were computed based on observation from five randomly selected rows.

iii) The average plant spacings and number of plants per 30 m of linear length under rice-sunflower crop rotation were somewhat low compared to the potato-sunflower rotation **(Tables 5** and **6)**. This was mainly due to soil moisture and tilth condition.

iv) The planting cost of sunflower using the locally manufactured FMI pneumatic planter was estimated at Rs. 359/ha as compared to Rs. 900/ha with the ordinary conventional seed-cum-fertilizer drill. Details of the economic cost estimation are shown in **Tables 7** and **8**. After germination Rs. 60-70/ha for thinning was the additional cost for the crop sown using the conventional drill. The FMI pneumatic planter used 3.7 kg of sunflower seed per ha as compared to 7.5 kg with the ordinary drill. The price of sunflower seed has been kept Rs. 150/kg (1993 price). Therefore, a farmer using the FMI pneumatic planter can reduce his production cost by Rs. 541/ha **(Table 9)**.

Conclusion and Recommendation

1. The overall performance of the locally manufactured pneumatic row-crop planter was satisfactory.
2. The planter is technically and economically viable, especially for planting sunflower, maize and cotton crops and has great potential for custom hiring.

Table 1. Mean Spacing (cm), Standard Deviation and CV(%) for Different Seed Plates (cotton)

Replication	Seed Plate Specifications											
	2-c			2-d			2-e			2-f		
	X	SD	CV	X	SD	CV	X	SD	CV	X	SD	CV
R1	15.0	5.1	33.9	19.8	5.4	27.0	24.7	8.9	36.0	24.8	8.6	34.9
R2	15.4	5.6	36.0	18.1	7.2	39.9	22.3	6.5	28.5	25.2	8.0	34.0
R3	17.3	5.6	32.3	17.9	5.8	32.5	22.0	5.5	25.0	22.0	6.9	31.0
Mean	15.9	5.4	34.0	18.6	6.1	33.1	23.2	7.0	29.8	24.0	7.8	33.3

Recommended spacing is 20-22 cm.

Table 2. Number of Plants per 5 Meter of Linear Length for Different Seed Plates (Cotton)

Sr. No.	Plate Specification	R1	R2	R3	X	SD	CV
1.	2-c	34	31	29	31.3	2.5	0.8
2.	2-d	25	28	26	26.3	1.5	8.5
3.	2-e	20	22	22	21.3	1.1	4.5
4.	2-f	20	21	24	21.6	2.0	6.9

Recommended number of plants per 5 m of linear length are 22-25.

Table 3. Percent Double/Hill Over a Linear Length of 15 Meters

Sr. No.	Seed Plate	R1	R2	R3	Average
1.	2-b	11	13	12	12
2.	2-d	51	52	54	52

Table 4. Number of Established Plants per 30 Meters of Linear Length

Variety	After Potato (Replication)						After Rice (Replication)					
	R1	R2	R3	R4	R5	X	R1	R2	R3	R4	R5	X
NK-265	110	113	119	98	100	108	84	107	90	87	108	95
SF-278	109	119	124	119	112	117	86	112	118	125	121	211
Contioil	108	102	98	108	99	103	99	102	90	92	36	84

Table 5. Mean Spacing (cm), Standard Deviation and Coefficient of Variation for Various Varieties of Sunflower (Potato - Sunflower)

Replication	NK-265			Contioil			SF-278		
	X	SD	CV	X	SD	CV	X	SD	CV
R1	26.6	6.0	22.7	23.9	8.5	35.5	26.2	10.1	38.8
R2	27.4	10.0	36.5	29.2	11.6	39.7	23.3	4.8	20.6
R3	25.3	6.4	25.3	24.4	9.9	40.6	24.0	6.5	27.0
R4	27.9	10.0	36.1	26.1	11.4	43.7	23.3	5.7	24.5
R5	28.2	12.6	44.7	29.3	9.1	31.0	24.0	7.8	32.5
X	27.0	9.0	33.3	26.6	10.1	38.1	24.16	7.0	28.7

Table 6. Mean Spacing (cm), Standard Deviation and Coefficient of Variation for Various Varieties of Sunflower (Rice - Sunflower)

Replication	NK-265			Contioil			SF-278		
	X	SD	CV	X	SD	CV	X	SD	CV
R1	34.2	20.8	60.8	34.7	14.7	42.4	41.0	17.9	43.6
R2	36.1	24.8	68.7	27.9	10.0	35.8	26.6	9.6	36.0
R3	32.8	16.7	50.9	31.8	14.2	44.6	26.3	9.6	36.5
R4	30.7	15.4	50.1	29.4	14.0	47.6	26.2	14.5	55.3
R5	28.2	15.7	55.7	50.8	38.0	74.8	24.4	9.6	39.3
X	32.4	18.68	57.2	34.92	18.1	49.0	28.9	12.2	42.1

X = Mean; SD = Standard Deviation; and CV = Coefficient of Variation.

Table 7. Fixed Cost Parameters

Parameter	Tractor Fiat-480	FMI-Pneumatic Planter	Seed-cum Fertilizer Drill
Purchase price (PP) (Rs)	295 500	35 000	8 500
Useful life (h)	10 000	1 200	1 200
Annual use (h)	1 000	150	150
Salvage value (% of PP/Yr)	10	10	10
Interest (% of PP/Yr)	14	14	14
Tex. ins. and shelter (% of PP/Yr)	2.5	2.5	2.5
Working width (m)		3.0	3.0
Travel speed (km/h)		5.0	5.0
Theoretical field capacity (ha/h)		1.5	1.5
Effective field capacity (ha/h)		0.83	0.6
Field efficiency (%)		55.3	40.0

Table 8. Variable Cost Parameters

Parameter	Tractor Fiat-480	FMI-Pneumatic Planter	Seed-cum Fertilizer Drill
Repair and maintenance rate (% of PP/Yr)	10	10	10
Labour requirement (man-h/ha)			
a) Skilled		1.2	1.67
b) Semi-skilled		1.2	1.67
Wage rate (Rs/ha)			
Skilled @ Rs. 90/8 h		13.50	18.78
Semi-skilled @ Rs. 65/8 h		9.75	13.56
Fuel consumption (ℓ/ha) (@ Rs. 5.00/ℓ)		3.83	2.0
Lubrication (Rs/ha) (15% of Fuel cost)		2.87	1.50

3. Design work for the further simplicity of the planter is needed, especially the replacement of poly-V belt drive to the vacuum fan and universal drives of the seed metering plates.
4. Fertilizer rate adjustments and uniform metering are need to be evaluated and made perfect.
5. Seed metering was almost perfect and no damage to the seed was observed.
6. There is a need to train operators about the operation of the planter, especially about the PTO drive, vacuum adjustments and depth control.
7. Extensive efforts are needed for its popularization.

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Table 9. Economic Comparison of Sunflower Planting System

Parameter	FMI-Pneumatic Planter	Seed-cum Fertilizer Drill
Planting cost (Rs./ha)	359.00	260.00
Cost of extra seed @ Rs. 150/kg for 3.8 kg/ha	—	570.00
Thinning cost (Rs/ha)	—	70.00
Total cost (Rs/ha)	359.00	900.00
Net benefit of pneumatic planter as compared to drill (Rs/ha)	541.00	

Design and Performance Evaluation of Axial Flow Blower with a Guide Vane for Spraying Orchards

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Abstract

Air-assisted spraying has been evolved as a unique method of spraying orchards all over the world because of its high efficiency and economy of operation. This study was aimed at developing an axial flow blower for an air carrier sprayer to be used with a 35-hp tractor. A new blower and three guidevanes were developed to meet the requirement of an air discharge of 4.5 m^3/s, and an outlet air velocity of 30 m/s. The blower was tested in combination with each of the three guidevanes. The blower with guidevane 2 gave the best overall performance. It could produce a discharge of 3.45 m^3/s, a velocity of 25 m/s and total air pressure of 1 100 N/m^2 with a maximum efficiency of 32.2% at the designed speed of 2 200 rpm. At higher speeds of the blower it showed better performance with an air discharge of 4.36 m^3/s, and exit velocity of 31.5 m/s at a speed of 2 800 rpm.

Acknowledgement: Sincere thanks are due to Mr. S.L. Patel, Director, ASPEE Research Institute, Bombay for the facilities he has provided for conducting the research work and also for his timely advice and other help.

Introduction

In India, spraying orchards is found to be a difficult and relatively uneconomical task due to lack of a suitable sprayer. The present method of using hydraulic sprayers is quite laborious, time-consuming and less efficient. Air-assisted spraying, a relatively new technology in the country, is best suited for tree spraying due to its advantages of uniform coverage, high deposition and efficient pest control. Since 35-hp tractors are most commonly used in the country, the high hp air carrier sprayers which are available in other countries are of no use. Therefore, it has become necessary to develop a suitable sprayer which can be matched with a 35-hp tractor.

Very few studies have been conducted at the ASPEE Research Institute, Bombay to develop a suitable blower for spraying orchards. Khade (1991) and Turare (1992) developed experimental axial flow blowers for orchards. Turare's design exhibited an overall poor performance whereas Khade's design suffered from a high power requirement. In this situation the present R and D work was undertaken as a continuation of the above studies with the following objectives:

(i) To design and develop an axial flow blower for spraying orchards;
(ii) To develop a guidevane for the blower; and
(iii) To evaluate the performance of the blower with a guidevane in the laboratory.

Design and Fabrication

Important design considerations were reached based on the

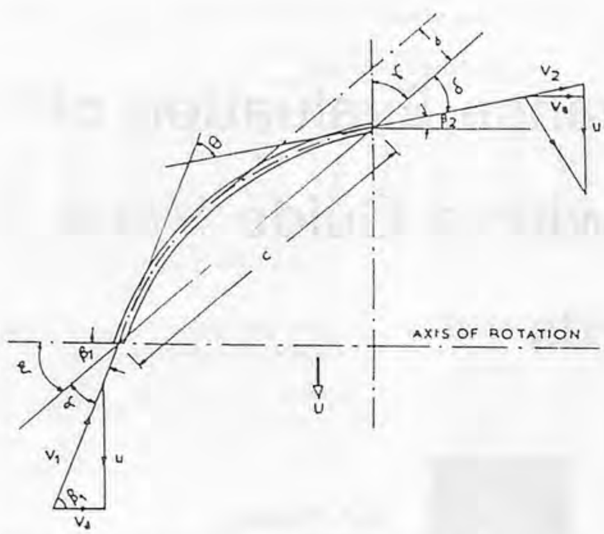

Fig. 1 Blade profile (cambered plate) with velocity triangles.

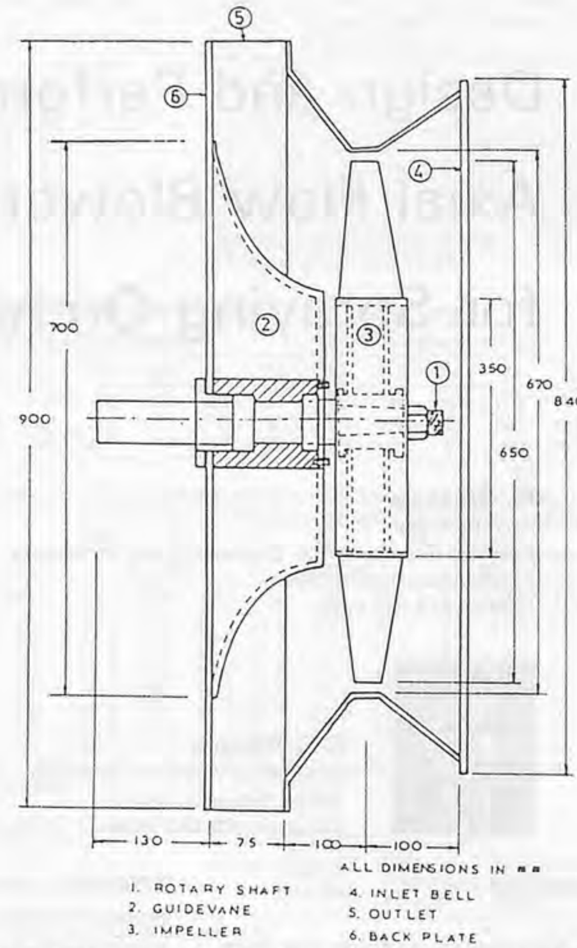

Fig. 2 Design details of axial flow blower with a guidevane.

past studies (Randall, 1971 and Turare, 1992). The Alphonso variety of mango crop was taken as a reference crop. The stabilized canopy size (the size of canopy when the growth get stabilized after active vegetative growth) of this crop was a trunkated cone approximately with 5 m base diameter, 5 m high, and 3 m apex diameter (Turare, 1992). It was assumed that the machine will spray one row of trees in a single travel at a ground speed of 3 kmph. With all the above assumptions the design objectives are given as follows:

i) Blower discharge should be 4.5 cu m/s as per the air displacement theory;
ii) Air velocity at the blower exit should be around 30 m/s;
iii) Blower efficiency should be above 35%; and
iv) Power consumption should be less than 14 kW.

Design of Impeller

(a) *Impeller diameter and design speed* — The impeller diameter (D) and design speed (N) were determined using the graphs of Q (air discharge), N and D given by Wallis (1983). The Boss ratio (v) was selected based on initial laboratory experiments conducted by the authors.

(b) *Blade angles* — The different blade angles are given by:

$$\beta m = \tan^{-1}[(1 - Es\lambda/2)/\lambda] \quad ...(1)$$

$$\beta_1 = \tan^{-1}(1/\lambda) \quad ...(2)$$

$$\beta_2 = \tan^{-1}[(1 - \lambda Es)/\lambda] \quad ...(3)$$

where

βm = mean blade angle, degree;
β_1 = blade inlet angle, degree;
β_2 = blade outlet angle, degree;
λ = local flow coefficient; = Va/U
Va = axial velocity of air, m/s;
U = linear velocity of blade at a given radius, m/s;
Es = local swirl coefficient; = $K_{th}\lambda/2$
K_{th} = mean total pressure coefficient; = $HTH/(0.5\ \varrho\ Va^2)$
HTH = total theoretical pressure required, N/m^2;
ϱ = air density, kg/m^3; and

Table 1. Design Dimensions of Blower

Parameters	Blade Radius, cm			
	17.50	22.75	27.63	32.5
Local flow coefficient (λ)	0.5263	0.4049	0.3334	0.2834
Local swirl coefficient (E)	1.0000	0.9070	0.7468	0.6348
Blade inlet angle (β)	62	68	72	74
Blade outlet angle (β)	42	57	66	71
Load factor (σC)	1.1600	0.8066	0.5316	0.3775
Chord length (c)	12.00	11.30	10.65	10.00
Solidity (σ)	1.06	0.714	0.53	0.40
Camber angle (θ)	28	26	21	18
Stagger angle (ξ)	53	61	64	69

Impeller diameter (D) = 65 cm.
Clearance between casing and impeller = 1 cm.
Boss ratio (v) = 0.538.

Va = mean axial velocity of air, m/s.

(c) *Chord length* — In order to determine the chord length (c) as shown in **Fig. 1** the load factor (σC_L) is found using the relation:

$$\sigma C_L = 2\,Es \cos(\beta m) \quad ...(4)$$

where
σ = solidity; and
C_L = lift coefficient.

Solidity (σ) was found by using a graph of σ versus λ with Es as a parameter as presented by Wallis (1983). Knowing σ, c can be found by

$$\sigma = n\,c / 2\pi (r/100) \quad ...(5)$$

where
n = number of blades;
= $6v/(1 - v)$
v = boss ratio (ratio of hub radius to tip radius); and
r = radius of the blade element considered, m.

(d) *Camber and stagger angles* — The blade camber angle (θ) and the stagger angle (ξ) **(Fig. 1)** were given by

$$\theta = \beta_1 - \beta_2 + 15 \quad ...(6)$$
$$\xi = \beta m - \alpha \quad ...(7)$$

where
α = incidence angle.

The value of α was obtained from the graph of α versus θ with C_L as a parameter as given by Wallis (1983).

The final design dimensions of the blower **(Fig. 2)** are shown in **Table 1**.

Design of Guidevanes

Three guidevanes called G1, G2 and G3, (characterized by their surface curvature) were designed with the inlet and outlet end diameters of 35 cm and 70 cm, respectively, **(Fig. 3)**. The curved surface of the G1 had three continuous curvatures of 15 cm, 18 cm and 20 cm R (radius), whereas the G2 had two continuous curvatures of 17 cm and 20 cm R and G3 had a single curvature of 20 cm R.

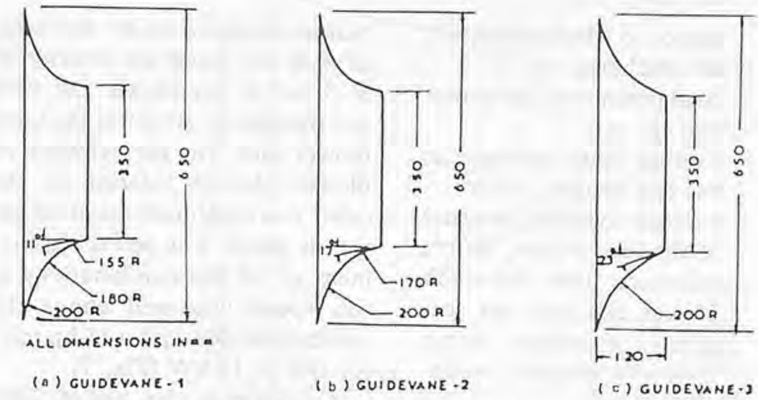

Fig. 3 Design details of guidevanes.

Fabrication

As per design dimensions, the blower and three guidevanes were fabricated. The impeller hub was made of 3 mm M.S. sheet and the blades were made of 2 mm M.S. sheet. The guidevanes were made of fibre glass plastic and the surface was painted in order to put a smooth finish.

Blower Testing

The blower was tested in the laboratory using a matching wind tunnel assembly. The performance was evaluated at four blower speeds of 2 200, 2 400, 2 600 and 2 800 rpm. A 40-hp AC motor was used to drive the blower. With the help of an ammeter and voltmeter, the current and voltage input to the motor were measured and later used to determine the input power. The speed of the blower was varied using different sprockets in the chain and sprocket power transmission system.

The static and dynamic heads at the test section in the wind tunnel were measured using a pitot tube and U-tube manometer as per AMCA specifications. To take care of the environmental effects, the dry bulb and wet bulb temperatures were measured using a psychrometer. From the psychrometer readings, dry air density and humid air density were determined.

The blower was tested in the laboratory in combination with each of the guidevanes and the performance parameters such as air velocity, air discharge, total exit pressure, power consumption and blower efficiency were evaluated using the following expressions:

$$Ve = Vt\,(AT/Ae) \quad ...(8)$$
$$Q = VtAt \quad ...(9)$$
$$pte = pe + pd + pl \quad ...(10)$$
$$Pi = (V\,I\,pf\,/1\,000)\,(\eta m/100)\,(\eta t/100) \quad ...(11)$$
$$\eta b = 100\,Q\,pte/Pi \quad ...(12)$$

where
Ve = exit air velocity, m/s;
Vt = air velocity at test section, m/s;
= $K\sqrt{Hd/100}$
K = velocity constant;
= $\sqrt{2\,g\,\rho w/\rho a}$
g = gravitational constant;
ρw = density of water, kg/m^3;
ρa = humid air density, kg/m^3;
Hd = dynamic head at test section, cm of water column;
At = area of test section, m^2;
Ae = area of blower exit con-

nected to wind tunnel, m^2;

Q = air discharge, m^3/s;

pte = total pressure at the blower exit, N/m^2;

ps = average static pressure at the test section, N/m^2;

pd = average dynamic pressure at the test section, N/m^2;

pl = pressure loss between blower exit and test section, calculated using Darcy-Weisbach's equation, N/m^2;

V = voltage input to the motor, volt;

I = current input to the motor, amp;

pf = power factor;

ηm = motor efficiency, %;

ηt = transmission efficiency, %; and

ηb = blower efficiency, %.

Results and Discussion

The test results are presented in **Figs. 4** through 7. It shows that the blower-G1 combination could produce a total air velocity of 32 m/s (**Fig. 4**), discharge of 4.41 m^9/s (**Fig. 5**) and a total exit air pressure of around 1 660 N/m^2 (**Fig. 6**) with a blower efficiency of about 29.6% (**Fig. 7**) at 2 800 rpm. Whereas blower-G2 combination produced an air discharge of 4.36 m^3/s and air velocity of 31.5 m/s at the blower exit with an efficiency of 30.2% at the same blower rpm. The performance of blower-G3 was inferior to the other two combinations at all the speeds tested. The power requirement of all the combinations at this speed was well above the power available with a 35-hp tractor that is 14 kW (**Fig. 7**).

Considering the power constraint, the best combination will be blower-G2 when operated in a speed range of 2 200 to 2 300 rpm (**Fig. 7**). At 2 300 rpm it could produce an air discharge of 3.63 m^3/s and an exit air velocity of 25.95 m/s with a blower efficiency of 30.5% and power consumption of 14 kW. This combination exhibited a maximum efficiency of 32.2% at 2 200 rpm which decreased gradually up to 2 700 rpm and again increased. It may be pointed out that the designed blower, in combination with G2, could produce an air velocity and air discharge close to the desired values as specified under design considerations. This particular blower can also be used with a 45-hp tractor also. In that case it can be operated at a higher blower speed of 2 600 rpm with a much better performance in terms of discharge and air velocity without much reduction in the blower efficiency. In the case of using a 45-hp tractor the blower-G1 combination is recommended since it gave a better performance at higher speeds except for a small reduction in the efficiency.

The difference in performance of the three combinations with change in the blower speed was mainly due to the hydraulic losses associated with the guidevane. Guidevane turns the air flow through 90° and the hydraulic loss due to this change in direction depends on the inlet velocity of air as well as on the curvature of the guiding surface. At 2 200 rpm the hydraulic losses were greater for G1 with its sharp curvatures of 150R, 180R and 200R from the inlet to outlet compared to G2 which had a smoother curvature of 170R and 180R, respectively. At higher velocities of air corresponding to a blower speed of 2 600 rpm and above, hydraulic loss is minimum for G1. Further studies are required for establishing the actual relationship between inlet air velocity, surface curvature of the guidevane and hydraulic loss due to the curvature for highly turbulent air flow like that in the

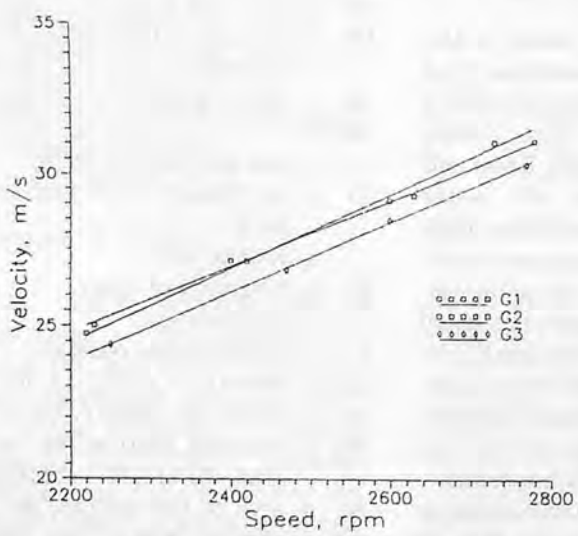

Fig. 4 Velocity characteristics of blower.

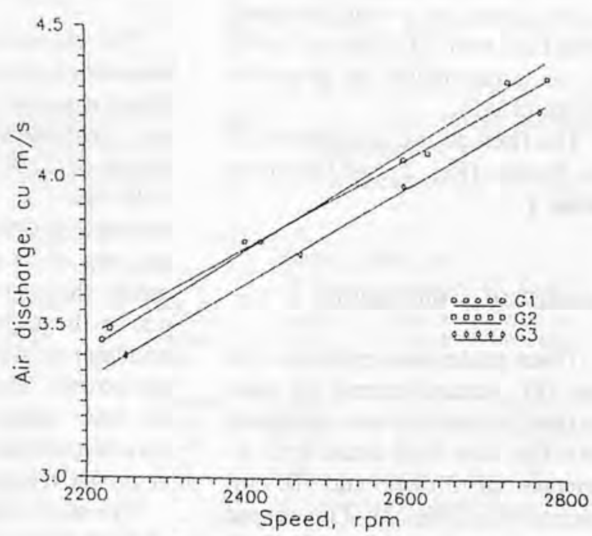

Fig. 5 Discharge characteristics of blower.

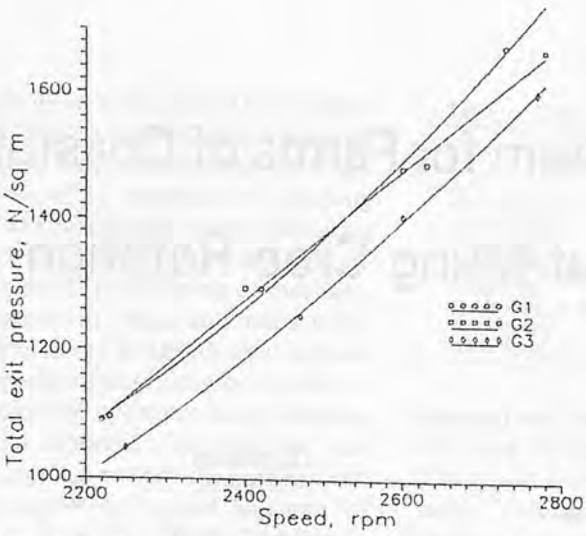

Fig. 6 Total exit pressure characteristics of the blower.

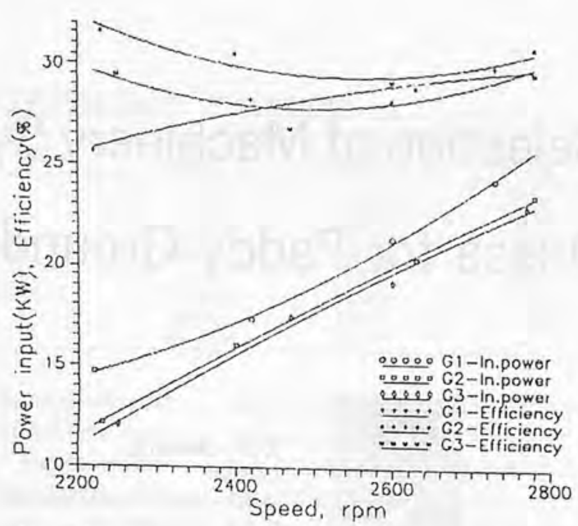

Fig. 7 Input power and efficiency characteristics of blower.

blower.

The performance of the blower was much better compared to the performance parameters like discharge and velocity of air and efficiency of blowers developed by Khade (1991) and Turare (1992).

Conclusions

i) A new axial flow blower was designed and developed with a guidevane to be used with a 35-hp tractor.

ii) The blower in combination with guidevane, G2 (with two continuous surface curvatures of 17 and 20 cm R) was best for a power input less than 14 kW (35-hp tractor is the power source) but the combination with guidevane, G1 (with three continuous curvatures of 15, 18 and 20 cm R) was superior with 45-hp tractors.

iii) The guidevane should be selected in accordance with the blower speed so as to reduce the hydraulic losses to a minimum.

The designed blower in combination with guidevane G2 driven by a 35-hp tractor is expected to cover one row of mango tree in one pass and spray 3 ha of mango orchard per hour. This is expected to be an ideal sprayer for farmers of India. However, the performance of the blower is required to be evaluated in the actual field conditions before final adoption.

Appendix

Table 1. Performance of Blower in Combination with Guidevane 1 (G1)

Parameter	Speed, rpm			
	2220	2420	2600	2730
Air discharge, m^3/s	3.45	3.78	4.06	4.32
Air velocity, m/s	24.73	27.10	29.10	30.99
Total exit pressure, N/m^2	1090.00	1294.00	1482.00	1674.00
Power consumption, kW	14.69	17.33	21.33	24.25
Blower efficiency, %	25.62	28.24	28.22	29.85

Table 2. Performance of Blower in Combination with Guidevane 2 (G2)

Parameter	Speed, rpm			
	2230	2400	2630	2780
Air discharge, m^3/s	3.49	3.78	4.08	4.33
Air velocity, m/s	25.02	27.12	29.26	31.02
Total exit pressure, N/m^2	1095.00	1295.00	1489.00	1668.00
Power consumption, kW	12.17	16.06	20.36	23.44
Blower efficiency, %	31.58	30.50	29.85	30.75

Table 3. Performance of Blower in Combination with Guidevane 3 (G3)

Parameter	Speed, rpm			
	2250	2470	2600	2770
Air discharge, m^3/s	3.40	3.74	3.97	4.22
Air velocity, m/s	24.39	26.82	28.46	30.26
Total exit pressure, N/m^2	1047.00	1253.00	1407.00	1602.00
Power consumption, kW	12.08	17.48	19.18	22.88
Blower efficiency, %	29.47	26.80	29.12	29.54

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Selection of Machinery System for Farms of Coastal Orissa for Paddy-Groundnut-Mung Crop Rotation

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Abstract

The selection of an optimum level of mechanization for different sizes of farm holds the key to a successful farm planning. This means the determination of optimum power source and its matching equipment for different farm sizes. In the present study the least cost method was adopted to determine the optimum size of power source and farm machinery. For a 5-ha farm a pair of bullock power along with an electric motor and its matching equipment are found suitable. Beyond that the power source should be a tractor for tillage, seeding, harvesting and an electric motor for post-harvest operations. In order to reduce the cost of operation and hour requirement it is advisable to mechanize the operations such as transplanting, seeding, weeding and harvesting which are time consuming and labour intensive.

Introduction

Orissa is situated in the eastern coast of India. It has a geographical area of 9.24 million ha with a cultivated area of 6.56 million ha of which a total of 2.9 million ha is irrigated and the rest depends on annual rainfall which is, on an average, 155 cm per annum (Annon., 1990-91). At present the Government of Orissa is giving a major thrust for the mechanization of farming operations. But mechanization without planning has no meaning. The mechanization planning has to be made keeping in view the land holding the cropping patterns, type of land, available irrigation facilities and, above all, an appropriate machinery system. Further, it is also important that each farm selects and utilizes the machinery available in the most effective manner in order to enhance profitability. This study selects the machinery system with appropriate power source to match it for farms of different sizes for the coastal Orissa which are well irrigated and fertile. Besides that, it has immense potential for multiple cropping. Keeping this in view the study proceeded with the following objectives:

(i) To select a level of mechanization suitable for different farm sizes;
(ii) To select the appropriate size of power source and their matching equipment; and
(iii) To determine the total annual system cost, total investment, total system hour/ha, and total energy requirement/ha for different farm sizes.

Review of Literature

Mcissac and Lovering (1974) developed a computer programme for determining the size of implements and tractor for least cost cereal tillage and seeding operations. But one major limitation was that the programme gave no guarantee about the consistency of size chosen for other operations such as harvesting, threshing and other farm operations. Faidley et al., (1975) developed a computer-aided technique for selecting and costing farm machinery. The main constraint in this model was that the given work should be completed within a specified duration of time. Singh and Gupta (1981) developed a method of selecting farm machinery system for farms of different sizes taking into account different levels of mechanization for wheat and maize crop. Shaloke et al. (1990) used a linear programming technique to determine the optimum farm planning and reported that with the new cropping pattern the profit could be increased 3.5 and 2.7 times for 1.5 ha and 5 ha farms, respectively. The cropping intensity could be increased from 135% to 280% and 135% to 214% for 1.5 and 5 ha farms, respectively. Isik et al., (1993) in his computer model named FMPS gave guidelines in selecting optimum sizes of farm machinery and tractor based on farm size, cropping pattern, soil properties and climate condition for the Sukurova region of Turkey. The model was designed to minimize the total cost of operation of farm machineries.

Table 1. Yield Loss Factor for Various Farm Operations

Operation	Yield Loss Factor kg/ha/day		
	Kharif	Groundnut	Mung
Ploughing	0.90	0.70	0.52
Harrowing	0.70	0.70	0.50
Planking	0.85	0.70	0.50
Sowing/transplanting	60.00	50.00	15.00
Irrigation	3.00	3.00	2.00
Inter-culture operation	10.00	2.00	1.00
Harvesting	10.00	10.00	1.00
Threshing	02.00	02.00	—

Economics of Farm Machinery

Land, labour, crops, capital and farm machinery make a farm. A good combination of all these elements makes a farm not only productive but also profitable. Farm machinery includes power units and their attachments to carry out different farm operations. The profit of a farm depends upon minimizing the cost of production thereby increasing the net return. The annual cost of operation of the power source and its attachments have to be minimized and the machinery system should be utilized properly for a profitable operation.

Machinery System Cost

The operation of a system of farm machinery is associated with: (i) fixed cost; (ii) variable cost; and (iii) timeliness cost. The annual cost (AC) is the summation of annual fixed cost, annual variable cost and annual timeliness cost. Fixed cost includes depreciation, taxes, interest, insurance and shelter. The variable cost includes cost of fuel, oil, labour, repair and maintenance. Timeliness cost arises because of farm machines inability to complete a farm operation in a reasonably short duration. There is a loss in net return when the yield and quality of the products are reduced because of delay in performing the operation during optimum period (**Table 1**).

The annual timeliness cost (ATC) for a certain farm operation can be estimated as follows:

$$ATC = (WHR - OWH) \times YL \times AUC \times PC/WHPD$$

where,

- WHR = Working hours required to perform certain farm operation, h
- OWH = Optimum working hours available for that farm operation, h
- YL = Yield loss due to delay, kg/day/ha
- AUC = Area under crop, ha
- PC = Price of that corp, Rs/kg
- WHPD = Working hours available per day for that farm operation.

Optimization Technique

The least cost method or minimization of total cost has been adopted in this study in order to determine the optimum power source, implement size, pumps and electric motor (Singh et al., 1981, Isik et al., 1993). In this method, if the first derivative of the function defining the annual cost is taken with respect to its size or capacity then the root of the resultant expression gives directly the optimum size causing the smallest annual cost. An optimum mechanization system consists of those tractors and machinery which are individually of optimum sizes. For example, the optimum size of a tractor-drawn implement can be determined by the following expression:

$$Wi_{(opt)} = [\sum_{I=1}^{NC} [10\{ \times A_{ij}/S_i \times E_i\} \times \{Lc_{ij} + TC + YL_{ij} \times A_j \times P_j/WHPD_i\}]^{1/2} \times [PPW_i\{1 - SVF/L_i + (1 + SVF) R/2 + SR/L_i + (1 + SVF) SC/2\}]^{-1/2}$$

Where,

- $Wi_{(opt)}$ = Optimum with of the ^{i}th implement, m
- NC = Number of crops
- A_{ij} = Area of ^{i}th field operation of ^{j}th crop, ha
- S_i = Speed of operation of ^{i}th implement, km/h
- E_i = Efficiency of ^{i}th field operation, in decimal
- LC_{ij} = Labour cost for the ^{i}th operation of ^{j}th crop, Rs/ha
- TC = Tractor cost/h, Rs./h
- YL_{ij} = Yield loss due to delay in the ^{i}th field operation of ^{j}th crop, kg/day/ha

A_j = Area under ^{j}th crop, ha
P_j = Price of ^{j}th crop, Rs/ha
$WHPD_i$ = Working hours per day for ^{i}th operation
PPW_i = Purchase price per unit width of ^{i}th implement
SVF = Salvage value factor, decimal
L_i = Life span of ^{i}th implement
R = Rate of interest
SR = Sale tax rate
SC = Shelter charge

Selection of Area

The optimum selection of farm machinery depends mainly on climate and crops of any region. The coastal districts of Orissa State have been selected for the following reasons:

(i) Most of the farms under cultivations are irrigated;
(ii) Multicropping system is followed; and
(iii) Farmers are aware of and interested in mechanization.

Selection of Crop

The farmers in the coastal Orissa districts are able to raise three crops in a year due to assured canal irrigation. Their cropping pattern is essentially a paddy-groundnut-mung crop rotation.

Operation Calender for Crops

Based on the recommendation made by agronomists at the College of Agriculture, OUAT, Bhubaneswar, Orissa, the optimum dates for various farm operations have been established. The farmers are required to perform different operations at certain periods. Therefore, the duration for each operation does not specify the optimum hours. The following formula is used to estimate the optimum hours available for each operation **(Table 2)** as follows:

$$OWH_i = \left(\sum_{J=1}^{n} ND_j/NO_j \right) \times WHPD_i$$

Table 2. Calender of Farm Operation for Paddy-Groundnut-Mung, Crop Rotation

Activity	Operation	Area	Optimum Operating Period
Paddy			
A	Nursery raising	—	June 15-July 10
B	Ploughing cum manuring	2A	July 01-July 10
C	Harrowing	2A	July 01-July 10
D	Planking	2A	July 01-July 10
E	Transplanting cum fertilizer application	A	July 10-July 15
F	First inter-culture	A	Aug 01-Aug 10
G	Fertilizer application	A	Aug 01-Aug 10
H	2nd inter-culture	A	Aug 30-Sept 05
I	Irrigation	As and when required	July 05-Oct 05
J	Management of pest and disease	A	Aug 15-Oct 15
K	Harvesting	A	Oct 25-Oct 25
Groundnut			
L	Tillage operation	2A	Oct 30-Nov 05
M	Harrowing	2A	Oct 30-Nov 05
N	Planking	2A	Oct 30-Nov 05
O	Sowing	1A	Nov 05-Nov 10
P	Fertilizer application	1A	Nov 15-Dec 05
Q	Inter-culture operation	2A	Nov 15-Dec 05
R	Irrigation	5A	Nov 25-Mar 01
S	Harvesting	1A	Mar 02-Mar 05
Mung			
T	Ploughing	2A	Mar 10-Mar 20
U	Harrowing	2A	Mar 10-Mar 20
V	Planking	A	Mar 10-Mar 20
W	Sowing	A	20-30 Mar
X	Fertilizer application	A	20-30 Mar
Y	Inter-culture	A	Nil (Not Required)
Z	Irrigation	—	Mar 15-Apr 15
A'	Harvesting	A	June 1-June 10

i = 1, 2, ... n, i = No. of operations, A - Net area sown in ha.

Where,
OWH_i = Optimum working hours available for ^{i}th field operation
ND_i = Number of days available for ^{i}th field operation
NO_j = Number of operations to be performed by the same power source during ^{j}th field operation
$WHPD_i$ = Working hours per day for ^{i}th field operations
N = Number of intervals during the period in which ^{i}th operation is performed.

Selection of Level of Mechanization

Basing upon the machinery use pattern adopted by the farmers in the coastal districts of Orissa the following four levels of mechanization were selected for the study:

(i) Animal and manual power source with few tillage machinery;
(ii) Animal and manual power source with few tillage machinery along with an electric motor to power stationary machines such as threshers;
(iii) Tractor as the power source for tillage and transportation and an electric motor to operate thresher and other stationary machines; and
(iv) Tractors as the power source for tillage, seeding, harvesting and transportation and an electric motor for operating the stationary machines.

Collection of Data and Computation

The field data were collected from selected areas through visiting farmers' fields during various stages of operation. The general information on animal, tractor, motor and implements were collected from various books and research works. The yield loss factor and irrigation requirement were collected from the agro-

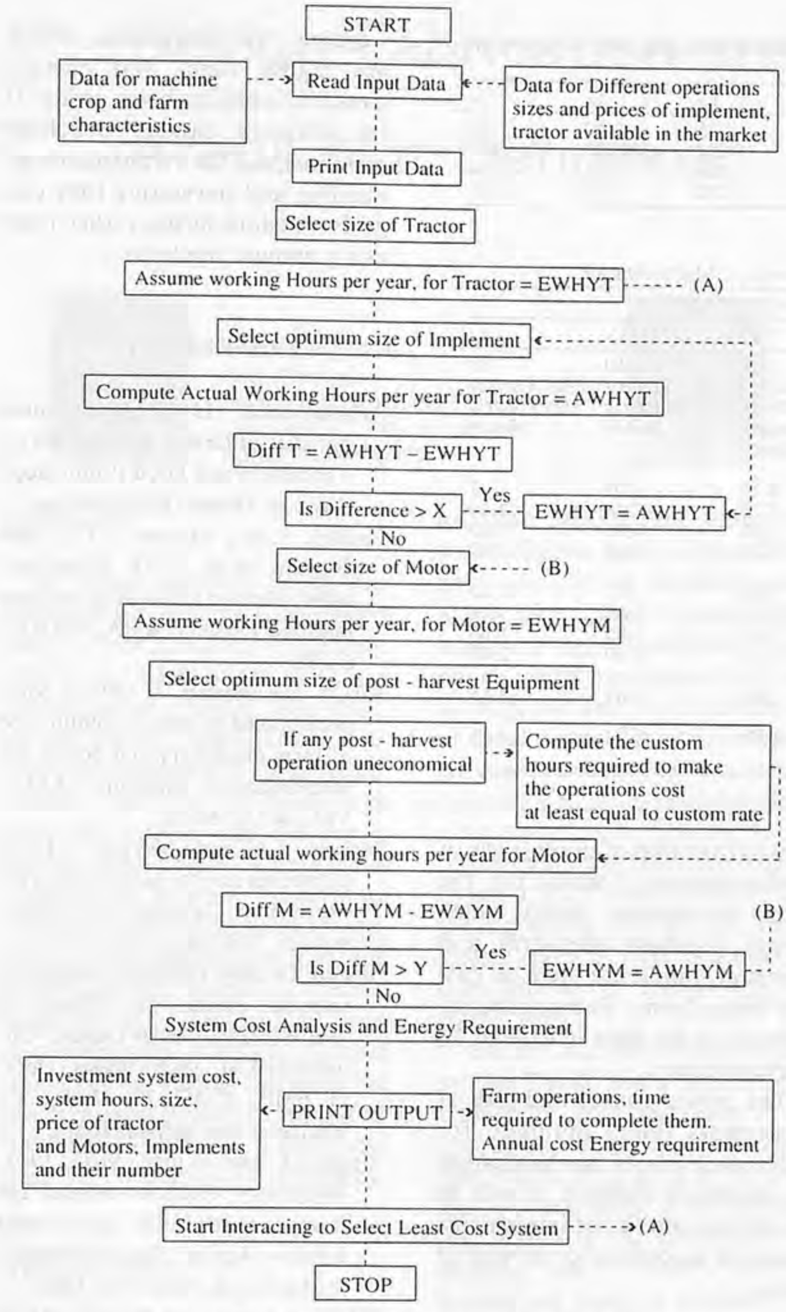

Fig. 1 Flowchart of programme used in the study.

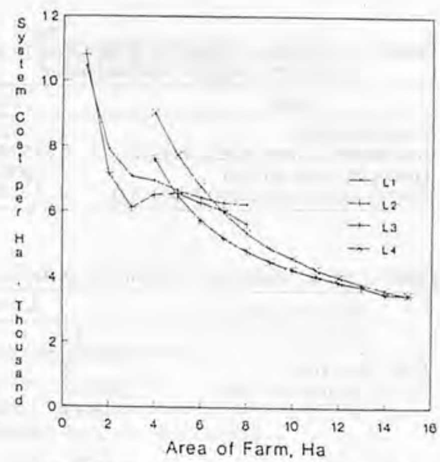

Fig. 2 System cost/ha (Rs) for different sizes of farms under four levels of mechanization.

nomists at the College of Agriculture, OUAT.

A computer programme was developed and written in BASIC for predicting system output which includes investment, total working hours/ha, optimum annual cost of operation, optimum power source and sizes of matching equipment. The flow chart of the programme is shown in **Fig. 1**.

Results and Discussion

The findings of the study are presented through **Tables 3** and **4** along with **Fig. 2**. The system cost/ha **(Fig. 2)** gives an idea about the level of mechanization suitable for different sizes of farms. For all the levels of mechanization the system cost gradually decreases as the farm size increases. In the case of L_1 and L_2 mechanization where the power sources are mainly human and bullock, the system cost/ha is almost equal for a 5-ha mechanized farm. Hence, it is suggested that L_1 and L_2 mechanization could be adopted for farms of 5 ha size where the initial investment is considerably less **(Table 3)**. But level-2 mechanization will be more suitable considering the fact that it includes an electric motor and a thresher which could be used for threshing paddy while the bullocks could be used for tillage for the succeeding crop. The system cost/ha for level-3 mechanization is almost equal to that of L_1 and L_2 for a 5 ha farm. But it can not be adopted due to high initial investment **(Table 3)**. Beyond 5 ha farm size it is not advisable to adopt L_2 mechanization although the system cost/ha gradually decreases because the power source then required will be two pairs of bullock which will incur considerable management cost. L_1 mechanization could be used for farm up to 2 ha size where the initial investment is comparatively less. The system cost/ha for L_3 and L_4 mechanization gradually decreases and becomes almost equal for a 15-ha farm size. So L_3 mechani-

Table 3. Investment, Hours of Work, Energy Input for Different Sizes of Farms for Different Level of Mechanization

Item	L_1	L_2	L_3	L_4
Farm size (ha)	2	5	10	10
Investment in farm machinery (Rs.)	13 500	19680	165 200	144 250
Hours of work (h/ha)	1 039	1 026	828	226
Energy input requirement (Mj/ha)	5 518	5 272	7 793	5 075

Table 4. Farm Machinery System for Different Level of Mechanization

Farm Machinery System	Level of Mechanization			
	L_1	L_2	L_3	L_4
Farm Size (ha)	2	5	10	10
Power Source and Size	Pair of bullocks	Pair of bullocks 1hp Electric Motor	25hp Tractor 1hp Electric Motor	25hp Tractor 1hp Electric Motor
Size/Capacity of Machinery				
M.B. Plough (m)	0.14	0.16	1.07	1.07
Die Harrow (m)	0.75	0.75	2.24	2.24
Wooden Planker (m)	2.00	2.00	4.00	3.60
Puddler (m)	1.20	1.20	NO	NO
Seed Cum-fertilizer Drill (m)	NO	NO	NO	1.20
Weeder (m)	NO	NO	NO	CH
Reaper (m)	NO	NO	NO	1.60
Paddy thresher (q/ha) (motor operated)	NO	1.25	2.00	2.00
G.N. thresher (q/ha) (motor operated)	NO	NO	NO	1.15
G.N. decerticator (q/ha) (motor operated)	NO	0.50	0.75	0.75

NO - Not owned, CH - Custom-hired.

zation could be adopted for farms up to 15 ha and beyond that L_4 mechanization should be adopted. But L_4 mechanization could be adopted for farms size of 10 ha and beyond considering the appreciable reduction in timeliness cost because of use of machinery in operation such as planting, weeding and harvesting.

Table 4 shows the system output for different sizes of farm under different levels of mechanization. Farm size of 10 ha is considered for L_3 and L_4 mechanization for easy comparison. The total hours of work/ha decreases gradually as the level of mechanization increases. In all the three levels of mechanization, except L_4, the maximum system hour/ha is required in such operations as transplanting, weeding and harvesting which are done manually. So it is very important to adopt mechanical methods to reduce the system hours/ha requirement. In L_4 mechanization, the system hour/ha is much less (226 h) than that of other levels of mechanization. Considering the initial investment, farms which cannot purchase seed-drill and harvester should use them on custom hiring basis. Energy requirement/ha is the least in case of L_4 mechanization.

The power source and size of implements found optimum for different levels of mechanization are shown in **Table 4**. It will be shown that the size of implements increases according to the size of farms.

Conclusion

L_2 mechanization could be adopted for farms up to 5 ha size and L_3 mechanization could be adopted for farms beyond 5 ha. To reduce the timeliness cost, L_4 mechanization should be adopted instead of L_3 for farms of 10 ha size and beyond. Mechanical methods should be adpted for operation such as transplanting, weeding and harvesting which are highly time- and energy-consuming besides being costly. If the farmers cannot purchase machineries for transplanting, weeding and harvesting they can go for custom hiring rather than using manual methods.

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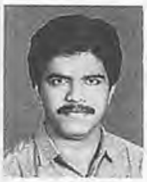
Design Fabrication and Testing of Areca Nut Dehusker



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Abstract

A power-operated areca nut dehusker was designed, developed and its performance evaluated. The major parts of the dehusker are the hopper, feeder, lead plate, cutting blade, shearing roller, friction plate and scraper. The feeder receives the dried and graded nut from the hopper and delivers it on the lead plate. The nut is compressed between the rotating shearing roller and the lead plate. The teeth on the roller peel off the husk and the kernel is ejected through the slot on the lead plate and the husk is removed. A single phase 0.5-hp motor operates the machine which gives an output of 9.0 kg dried nut/h for a single unit with 84.5% dehusking efficiency.

Introduction

The evidences that can possibly be adduced on the antiquity of areca nut of the multifarious uses to which it is put in our every day life bear out amply that the areca nut has been in cultivation and use in India, from the time immemorial. With an annual production of 191 400 t, India ranks first among the countries producing areca nut.

The areca nut palm occupies a prominent place among the cultivated cash crops in the country and has considerable economic, socioreligious and medicinal importance. The nut proves its use as a medicine against leucoderma, leprosy, cough, fits and obesity. It has also been mentioned for its use as purgative and for the treatment of nasal ulcers. The major chemical constitutents of the nut include polyphenols, fat, poly saccharides, fibre and protein. The cultivation of the palm provides employment to about 6.25 million people and the marketing of areca nut brings sizable revenue to the states exchequer (Survey of Indian Agriculture, 1992).

Studies and surveys conducted by the Tamil Nadu Agricultural University, with reference to the cost of processing areca nut show that about 35 to 40% of the total cost of processing is for dehusking, which is currently done by women folk. Country kitchen knives are used to separate the kernel from the dried nut. This conventional method is highly labour intensive and time-consuming and above all, uneconomical. Mechanical dehuskers even for small-scale dehusking are not commercially available. One dehusker which has been developed earlier is not fully successful in meeting the requirements of dehusking.

In an attempt to overcome the problems associated with dehusking, the present study was undertaken at Kelappaji College of Agricultural Engineering and Technology, Tavanur with the objectives of designing and fabricating an areca nut dehusker and to evaluate its performance.

Materials and Methods

Three models, viz. impact type, scissor type and shearing type were developed. The problems encountered in each model and the advantages of each were studied on the basis of which an areca nut dehusker was developed and its performance evaluated. The dehusker comprises of a hopper, feeder, lead plate, shearing roller, cutting blade friction plate and husk scraper as shown in **Figs. 1** and **2**.

The functions of each part and their materials of construction along with specification are as folllows:

Hopper

The hopper is made of 24 gauge G.I. sheet and has a capacity to carry 2 kg of dried areca nuts. There is an opening at the bottom of the hopper through which the kernels come out.

Feeder

This is a cylindrical feeder with a diameter of 145 mm and length

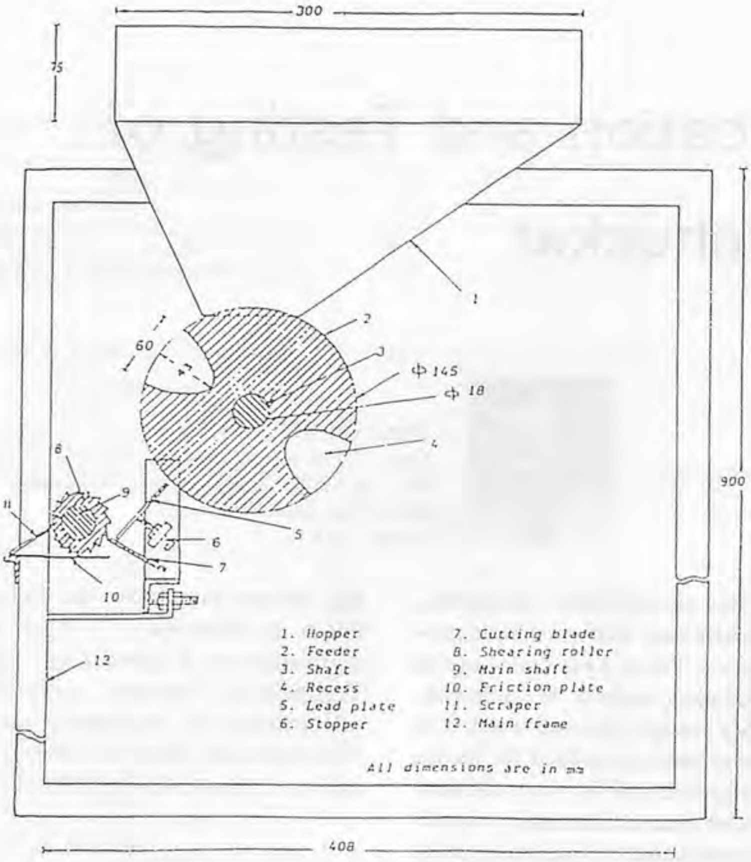

Fig. 1 Sectional view of the areca nut dehusker.

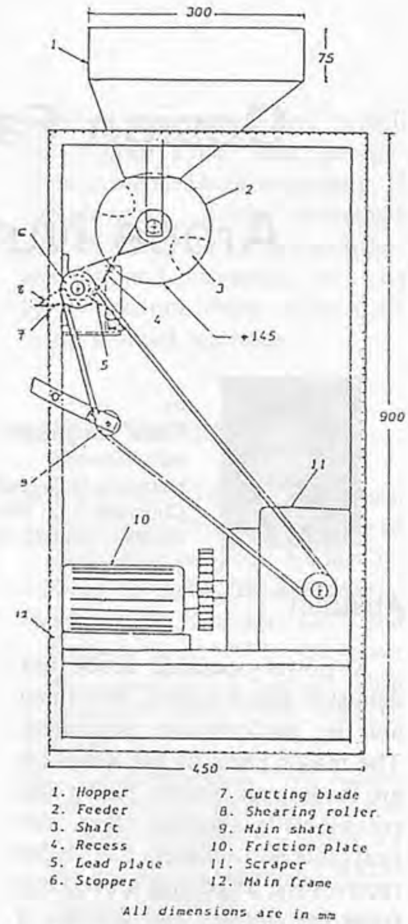

Fig. 2 Side view of the areca nut dehusker.

of 45 mm and is made of wood. There are two U-shaped recesses 60 mm. wide and 43 mm deep on its periphery as shown in **Fig. 1**. The nuts falling under gravity from the hopper is received in a recess one at a time. As the feeder is rotated, the nut gets transferred and discharged at the dehusking zone.

Lead Plate

The lead plate is made of 3 mm thick M.S. flat that is provided near the shearing roller as shown in **Fig. 1**. This flat plate of size 65 × 45 mm leads the nuts discharged by the feeder into the shearing roller. There is a 33 × 30 mm slot at the bottom in its centre which serves as the outlet for the kernel after dehusking. The lead plate can be adjusted to the required angle.

Cutting Blade

The cutting blade is provided just below the lead plate and is made of 3 mm thick M.S. flat of size 65 × 39 mm. The angle of the blade can be adjusted. The lead plate and cutting blade are integrated into a single unit with provisions for adjusting the distance of this unit from the shearing roller in vertical as well as horizontal direction.

Shearing Roller

The shearing roller is the heart of the machine. It has 16 teeth of 80 mm long and 3 mm high, on its periphery. The roller is fixed on the M.S. main shaft which is 21 mm in diameter and 420 mm long. The main shaft along with the shearing roller is driven by a belt drive.

Friction Plate

It is made of 3 mm M.S. flat and 90 × 40 mm in size, fixed just below the shearing roller. The husk separated from the fruit is caught in between the shearing roller and friction plate and carried away by the shearing teeth.

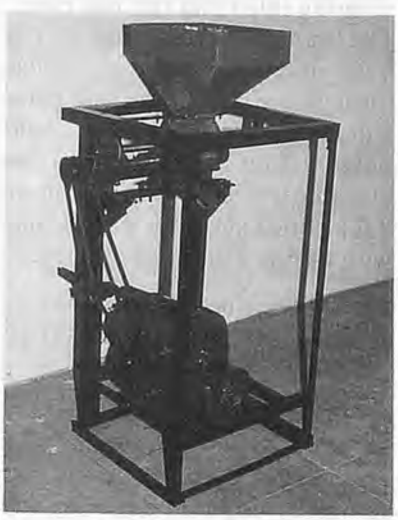

Fig. 3 Isometric view of the areca nut dehusker.

Husk Scraper

The scraper helps in removing any portion of the husk sticking to the teeth before the teeth return for the next cycle of dehusking.

A single phase 0.5 hp electric motor of rated speed 1 445 rpm

Fig. 4 Isometric view of the shearing roller.

was used to derive the power driving the machine.

Experimental Procedure

The machine was tested at different levels of speed, blade angle and slot angle (lead plate angle) as shown below:

Speed: 25, 35, 45 rpm
Blade angle: 60°, 70°
Slot angle: 135°, 140°, 145°

Dried areca nuts were randomly selected and is fed into the shearing roller. The number of nuts fully dehusked and those kernels damaged were recorded. The dehusking efficiency and damage were calculated as follows:

Dehusking efficiency (%)

$$= \frac{\text{No. of dehusked fruits}}{\text{Total No. of fruits fed}} \times 100$$

Damage (%)

$$= \frac{\text{No. of damaged kernels}}{\text{Total No. of fruits fed}} \times 100$$

Results and Discussion

The dehusking efficiency of the machine varied from 20.0% to 84.5% and the percentage of damaged kernels varied from 10 to 40 under different machine set-up as shown in **Table 1** and graphically represented in **Figs. 5** to **7**.

It has been observed that as the speed of the roller increases, the peripheral velocity obtained by the teeth of the roller increases and the nuts are deflected away from the roller and does not allow the teeth to pierce the husk. When the blade angle is increased from 60° to 70° the nut is pushed further down along the lead plate, compressed and thus prevented from rolling. As a result the dehusking efficiency was reduced. At 135° of the slot angle, the space between the roller and the lead plate is reduced, leading to the compression of the nuts and thereby lowers the efficiency and low damage. At 140°, this space increases and the nut is deflected away from the roller causing low dehusking efficiency.

A computer analysis was carried out to understand the effect of each parameter. A 3 × 2 × 3 factorial experiment for a

Table 1. Dehusking Efficiency and Damage at Different Machine Set-ups

Set-up No.	Speed (rpm)	Blade angle (degree)	Slot angle (degree)	Dehusking efficiency (percent)	Damage of kernel (percent)
1	25	60	135	30.0	30.0
2	25	60	140	77.1	20.0
3	25	60	145	50.0	10.0
4	25	70	135	40.0	30.0
5	25	70	140	60.0	20.0
6	25	70	145	30.0	10.0
7	35	60	135	20.0	40.0
8	35	60	140	84.5	10.9
9	35	60	145	70.0	10.0
10	35	70	135	40.0	20.0
11	35	70	140	74.2	11.1
12	35	70	145	40.0	40.0
13	45	60	135	30.0	30.0
14	45	60	140	70.0	10.0
15	45	60	145	30.0	20.0
16	45	70	135	30.0	10.0
17	45	70	140	50.0	20.0
18	45	70	145	20.0	20.0

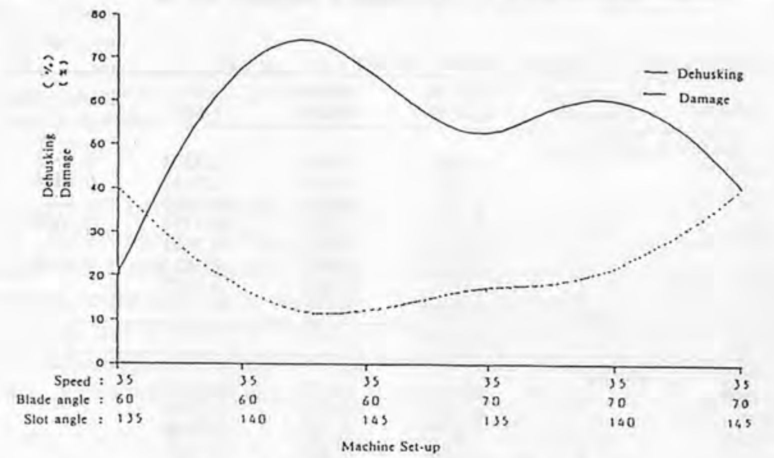

Fig. 5 Dehusking and damage at 35 rpm.

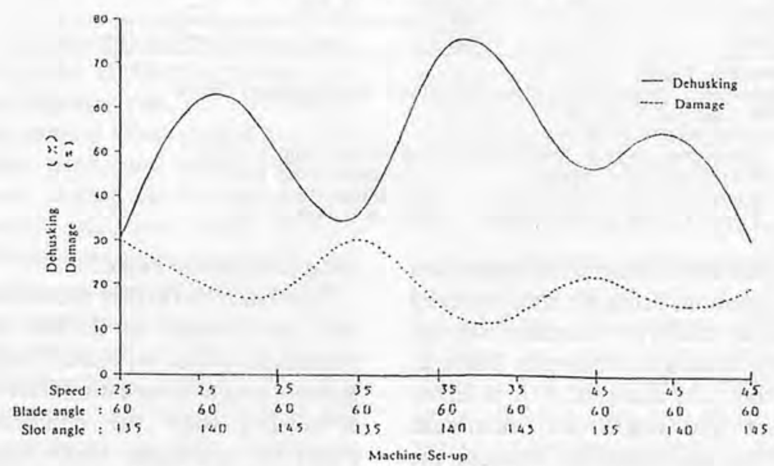

Fig. 6 Dehusking and damage at blade angle of 60°.

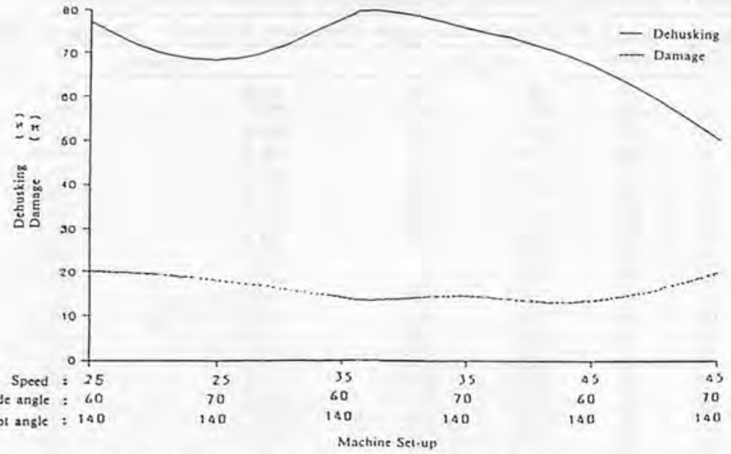

Fig. 7 Dehusking and damage at slot angle of 140°.

Table 2. Results of Computer Analysis of Data

Source	Degrees of Freedom	Sum of squares	Mean square	F Value	Probability
A: Variable 5: Dehusking					
Factor A	2	1.011	0.506	2.3201	0.1015
Factor B	1	0.450	0.450	2.0652	0.1526
AB	2	0.033	0.017	0.0765	—
Factor C	2	6.178	3.089	14.1756	0.0000
AC	4	0.656	1.164	0.7521	—
BC	2	0.933	0.467	2.1416	0.1208
ABC	4	0.433	0.108	0.4972	—
Error	162	35.300	0.218	—	—
Total	179	44.994			
B: Variable 5: Damage					
Factor A	2	0.044	0.022	0.1277	
Factor B	1	0.022	0.022	0.1277	
Factor C	2	0.278	0.139	0.7979	
AC	4	0.356	0.089	0.5106	
BC	2	0.544	0.272	1.5638	0.2125
ABC	4	0.489	0.122	0.7021	
Error	162	28.200	0.174	—	
Total	179	29.978	—	—	

Function: Factor
Experiment Model: Three factor completely Randomnized Design
Data Case No. 1 to 180
Factorial ANOVA for the factors:
Replication (Var 4: Replication) with values from 1 to 10
Factor A (Var 1: Speed) with values from 1 to 3
Factor B (Var 2: Blade angle) with values from 1 to 2
Factor C (Var 3: Slot angle) with values from 1 to 3

completely randomized design was carried out using hte data obtained under different machine set-up. The results are shown in **Table 2.** From this analysis, it is inferred that slot angle has maximum effect on dehusking because the F-value for this factor is 14.1756, and falls on the rejection region. Whereas the corresponding F-values of 2.3201 and 2.0652 for speed and blade angle lie on the acceptance region. Therefore, it is concluded that the changes in speed and blades angle do not influence the dehusking efficiency much. But the change in speed has more effect compared to the change in blade angle.

The analysis further shows that with an F-value of 2.1416 the combined effect of blade angle and slot angle has greater effect on dehusking than the combined effect of speed and blade angle and also the speed and slot angle. The F-value of 0.7521 for the combined effect of speed and slot angle implies that it has more influence on dehusking as compared to the simultaneous effect of speed and blade angle which has a lower F-value of 0.0765.

A factorial analysis to determine the effect of operational parameters on damage showed that a combined effect of blade angle and slot angle is the most significant factor causing the damage. Due to an F-value of 0.7979, the factor slot angle has higher influence on damage than the other two factors. The change in speed and blade angle do not have substantial effect on damage of kernel and found that both have the same degree of influence.

Of the 18 experimental set-up of the machine, a maximum efficiency of 84.5% was obtained for a blade angle of 60°, slot angle of 140° and speed of 35 rpm. The damage was 10.9% which is only slightly higher than the minimum of 10% caused by the machine. At this set-up the output of the machine will be 9 kg of dried nuts/h.

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Assessment of Two-dimensional Vehicles for Rural Transportation in the Savanna Region of Nigeria

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Abstract

A survey of travel habits and transport infrastructural needs in selected rural areas of Savanna Region of Nigeria is reported in this paper.

Most of the short-distance trips (0-5 km) which constituted over 74% of the total trips were for farming and getting domestic needs. The medium distance trips (6-20 km) which constituted 17% were for marketing while the remainder (over 20 km) were for religious and social activities. The foot-path was dominant as route and the mix of vehicles owned and used were headportage, animal, bicycle, motorcyle and 4-wheel vehicles. The average load capacity utilization factors for the first four vehicles were 63, 61, 53 and 46%, respecitvely. The commonly owned vehicles were bicycles and motorcycles at an average of 1.5 and 0.4 per household, respectively.

The survey shows that since each class of trips constituted invaluable role in the life of rural households, the provision of a graduated choice of transport vehicles which would include manual, animal and mechanical power system would ideally meet their travel needs. Both bicycle and motorcycle, being two-dimensional, would for now fit the existing route and meet most of the rural travel needs. However, their capacity utilization would need to be improved upon.

Introduction

Rural areas in developing countries such as Nigeria represent not just country side, but also part of the country where people and their basic needs and services such as food, shelter, clothing, education, health, etc. are widely spaced. These rural areas are a large and important segment of the developing countries. Transport relates to the means of conveyance which enable people to reach the things important to them. The type and intensity of transport needed are generally dictated by the type and intensity of man's basic needs. To this effect, ILO[1] (Howe, 1993) has defined local rural transport system as that which people in the rural communities need for shelter, food, water and clothing, etc. Related studies have indicated that the trip of direct relevance to the rural households were made to farm, market, hospital, school, for domestic needs, social and religious activities. In India, Kenya and Mexico, trips by households to farm, market and for domestic needs amounted to 80, 5 and 15%, respectively. In terms of trip distance, most trips were within the village neighbourhood with 75-80% being less than 7 km in length. Also, the average trip load in Kenya was 25 kg (Barwell 1977, Adebisi 1982, Howe 1983).

With footpath being dominant as the route in the rural areas, the mix of vehicles used in rural areas were headportage, animal, bicycle, motorcycle, and the 4-wheel vehicle (Adebisi. 1982; Adeoti, 1988). Studies on ownership pattern show that in India 74% of households did not own any form of transport devices, while 17,9, and 1% of the households owned an animal, a bicycle, and 4-wheel vehicle, respectively (Howe, 1983), Although transport remains an essential function at all levels of income, there is a relationship between income level and vehicle ownership. In the U.S.A, India and Malaysia, the 4-wheel vehicle ownership was significant only in urban households with high in-

[1]ILO is the acronym for International Labour Organization.

come while motorcycle and bicycle ownership extended into the lower income group (Zhavi, 1976; UNIDO[2]; 1978, Howe, 1983) The bicycle and motorcycle, by their configuration, are referred to as "two-dimensional" devices. Both are identical except for their power system. While the bicycle is manually pedalled, the motorcycle is powered but the latter developed from the former. Historically, the development of bicycle started in 1860 (Whitt and Wilson, 1985). Since then, greater machine development have taken place, including the rail, water and air vehicles such that the average person, especially in developed countries, would consider the "bike" as a monument of an age gone by. Today millions of people are riding bicycles not only for sport but for exercise and transportation.

Appropriate technology is that technology which is simple, low-cost, labour-intensive and decentralized, especially for the rural environment (OECD/FAO[3], 1976). This is not as sometimes been stated "second best" technology. Often, a high level of design expertise is necessary to produce an operational, simple, yet economic design for local manufacture and usage. The relevant criteria for measuring the appropriateness of technology are technical, economic and sociopolitical factors. It generally has high degree of appropriateness within the given environment and confined to locally available inputs (Schemacher, 1976).

This paper discusses the appropriateness of "two-dimensional" vehicles for rural transportation based on findings from a survey of rural transport needs and existing transport infrastructure in the Savanna Region of Nigeria.

[2]UNIDO is the acronym for United Nations Industrial Development Organization.

[3]OECD/FAO is the acronym for Organization for Economic Cooperation and Development and Food and Agriculture Organization of United Nations.

Data Base

The bulk of the information presented in this paper was gathered through direct interview of rural households. The study sites were located in parts of Kaduna and Kastina States of Nigeria. These States stretch from latitude 9°N to 13°N 15′ and are in the centre of Guinea Savanna vegetation region which covers more than one-third of the country.

The area is most conducive for agriculture which is the main industry in the rural area. Using hand tools, the major crops grown are sorghum, millet, groundnuts, cotton yams, cassava, cowpea, maize, tomatoes, pepper, etc. (Abalu, 1978). Because farming practices and general living conditions are similar within the savanna region, conclusions from the study site should be applicable to the remaining savanna vegetation belt of the country. The questionnaires were administered to samples of household heads in the study sites. Some aspects covered in the survey are household composition, travel characteristics in terms of purpose, volume and frequency; vehicle ownership, packaging method and materials, vehicle capacity and utilization.

Results and Discussion

Travel Needs of Rural Households

The mean of the household size covering all age group was 9.4 persons. However, for this study it was considered that the age group likely to be directly involved in trip-making are the elementary school age and above. For this age group, the mean of the household size was 7.6 persons.

With the basic definition of a trip as one-way movement which takes a member of a household out of an area to meet a specific need; trips in the rural area were found to fit into the following categories:

i) Trips to farm : to perform any farming operations.
ii) Trips to market : to buy or sell farm inputs or outputs and other things for the family or retailing.
iii) Trips for domestic needs : for getting things for the family other than from the market such as water, firewood, local building materials etc.
iv) Trips for social, religious, or recreational activities: such as trips to partake in ceremonial festivals, marriage, birth, burial etc.
v) Other trips : to school (teacher, pupil): hospital (staff, patient) administration (village head) etc.

It was observed that some trips were undertaken for more than one purpose. For example, a trip primarily intended for farming operation might include fetching fire wood for the family. During the survey the primary purpose for each trip was asked for.

The results of the trip purpose characteristics which are indicators of travel needs are presented in **Table 1**. This result reveals that, on the average, the relative frequency distribution of all trips undertaken were 69, 11, 6, 9, and 4% for trips to farm, market, domestic needs, social/religious and other purposes, respectively. This result confirms the earlier notion that the major occupation of the site was farming. The short distance trips (0-5 km) amounted to over 74% of the total trips of which over 75% were for farming and domestic needs. The medium distance-trips (6-20 km) which constituted 18% were to market

Table 1. Characteristics of Trip Distance Relative to Trip Purposes for Households Resident in Rural Areas

Travel Distance (km)	Average Number of Weekly Person-Trips/Household						
	Trips to farm	Trips to market	Trips for domestic needs	Trips for sol/Relacti vities	Others (Hospital, school, etc)	Sub-total	Relative trip freq. (%)
0-2	32.9	1.0	1.5	0.5	1.4	37.2	41.0
3-5	23.5	3.2	2.1	1.2	0.5	30.5	33.6
6-10	4.7	2.2	1.2	1.7	0.7	10.5	11.6
11-15	1.0	1.0	0.3	1.3	0.1	3.7	4.1
16-20	0.1	1.0	0.3	0.5	0.3	2.2	2.4
21-50	0.2	0.9	0.3	1.4	0.6	3.4	3.7
50-100	0	0.6	0	0.8	0.3	1.7	1.8
>100	0	0.4	0	1.2	0.1	1.7	1.8
Total	62.4	10.3	5.7	8.4	4.0	90.9	100.0
Percent of total	68.6	11.3	6.3	9.4	4.4	100.0	—
Average distance	3.1	23.1	6.1	43.4	31.1	—	—

and farm while the long distance trips (above 20 km) which constituted only 7% were for social and religious purposes. The trip mean distances were significantly different for the different purposes; while trips for farming and domestic needs were essentially short distance-trips, the social and religious functions were of long distance-trips.

Another rural travel need parameter measured relates to goods haulage. With the exception of grains and tubers which were transported in bulk and mostly during harvest season; the all season goods include farm inputs and implement such as seed, fertilizer, hoe, cutlass and farm outputs which are mostly vegetables. For these all season goods haulage, the average trip load was 27 kg. Generally, in the rural area, problems of goods movement is more acute than person movement. At least since major trips were short distant, walking-mode was available though the least efficient.

The Rural Roads

The trip linkages in the rural areas can be divided into two segments, namely:

(i) from the interior, mainly farmland, etc. to the access/feeder roads; and
(ii) from the access road to market centers, storage points, etc.

With the bulk of rural household activities relating to farming, the origin and destination of most journeys were from the farm to the villages storage centers or immediate market centers with their location in the 'interior' i.e., off the access road. At best, they are linked with unpaved roads which are not motorable during some parts of the year. The common route for all year transport was foot-path. These unpaved roads and foot path had width that ranged from 0.3 to 1.8 m depending on the season. the variations in the width were mainly due to overgrown weeds along the route, especially during the weeding and harvesting season.

Vehicle Ownership Pattern

With foot-paths as dominant routes, the mix of vehicles for conveyance encountered were walking/headportage, animal pack, bicycle, motorcycle and 4-wheel vehicles **(Fig. 1)**. The 4-wheel vehicles were taxi, pick-ups, mini-buses and tractor-trailer. The ownership distribution of these vehicles are presented in **Table 2**. On average, 1.5, 0.4, 0.2, and 0.06 bicycles, motorcycles animals, and 4-wheel vehicles, respectively, were owned per household. Also 73, 30, 16, and 5% of the households owned at least a bicycle, motorcycle, animal or 4-wheel vehicle, respectively, while a few households owned more than one vehicle. However, with an average household size of 7.6 persons actively involved in trip making, the low number of vehicles per

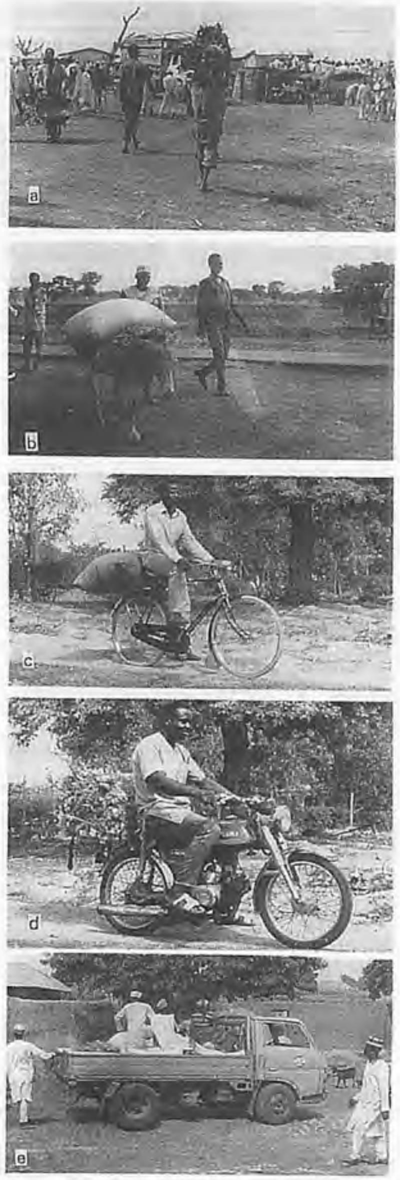

Fig. 1 Current travel modes in rural areas of Nigeria (a. Walking/headportage, b. Animal, c. Bicycle, d. Motor cycle, e. 4-wheel-vehicle).

household clearly indicated that walking/headportage was widely used. It was also observed that non-residents of the rural areas owned the 4-wheel vehicles that plied the rural routes, especially on occasions such as marketing. Also, there were hiring services using bicycle and motorcycles in the area.

With regards to sources of financing the transport devices, over 70% of the respondents bought their vehicles from family source funds, the remaining bought with loans from relations

Table 2. Distribution of Vehicles Owned per Household

Number of Vehicles Owned per Household	Relative Frequency of Vehicles per Household			
	Animal (donkey, mule horse, etc.)	Bicycle	Motorcycle	4-wheel vehicle (taxi, pick-up, tractor, etc.)
0	84.2	27.4	69.8	95.0
1	9.5	26.6	18.5	4.0
2	6.3	22.4	11.7	1.0
3	0	13.7	0	0
4	0	4.8	0	0
5	0	2.7	0	0
6	0	1.5	0	0
7	0	0.9	0	0
8	0	0	0	0
Average per Household	0.2	1.5	0.4	0.06

and friends. None indicated purchasing their vehicles with bank/government loans. The preponderance of bicycle and motorcycle ownership is noteworthy in view of the existing all-season track and the economic level of rural household.

Rural households indicated strong preference for self ownership of vehicle such that constant availability and service reliability would be assured. This is preferred for some type of farm products. Some of the common and all season crops in the region were vegetables, namely; tomatoes, onions, garden eggs, okra; pepper etc. These, when harvested, had to be transported almost immediately to avoid spoilage.

Performance of Existing Vehicles

Part of the survey included users' assessment and ranking of performance of vehicle attributes such as:

i) speed: capacity to convey users to destinations in good time;
ii) load carrying capacity: capacity to convey users and their loads;
iii) reliability: safety and readily available for use; and
iv) Cost: capacity to bear the cost (fixed and variable) of owning the vehicle and on cost effective basis.

The results indicate that rural households considered vehicle load carrying capacity and reliability to be more important attributes than speed and cost. The results also indicate that goods-movement was more acute than human transportation, at least since major trips being short-distance, walking mode was available. While bicycle was rated as being the best in terms of reliability and cost, followed by motorcycle; both were rated low on load carrying capacity. In relation to good-haulage, the existing packaging devices and methods varied in shapes and sizes. These included woven baskets, jute bags and bundle system, especially for firewood, sorghum, and building materials (**Fig. 2** and **Table 3**). These packages facilitated handling as well as served as measuring devices in rural marketing. The vehicles used also varied with the goods, its pattern of maturing, physical characteristics and packaging systems. Both grains and tubers matured and were generally transported in bulk. In contrast, vegetables were all seasonal crops and were harvested and transported piece-meal. Generally, the quantity per harvest for individual households ranged between 17 kg and 85 kg. Each harvest was packed in baskets or juste bags in order to minimize spoilage (**Fig. 2**).

Fig. 2 Current packaging materials and methods in rural areas (a. Woven baskets for tomatoes, b. Jute bags for maize, c. Rope bundle for fire wood).

The findings relating to the performance of current vehicles are presented in **Table 4**. At full capacity, pack - animal, bicycle, and motorcycle had 250,500 and 4000% potential performance advantage, respectively, to head portage. Both bicycle and motorcycle have added advantage of

Table 3. Characteristics of Typical Packing Materials and Methods in Rural Area of Nigeria

Packaging material	Shape and critical dimensions (mm)	Volume ($\times 10^{-3}$) (m^3)	Goods content	Average gross weight of goods at full load (kg)
Basket	Conical shape (top dia × bottom dia × depth)			
	i. 550 × 340 × 340	49.9	Tomato	40.0
	ii. 540 × 350 × 310	41.2	Tomato	35.2
	iii. 480 × 270 × 220	27.2	Tomato	20.0
	iv. 550 × 330 × 360	57.8	Okra	29.0
Jute bags	Cylindrical shape (dia × length)			
	i. 470 × 1 030	178.7	Onion	100
	ii. 330 × 770	71.20	Sweet-pepper	24
	iii. 470 × 1 040	180.4	Maize	103
Rope bundle of unthreshed materials	Cylindrical shape (dia × length)			
	i. 1 770 × 750		Guinea-corn	40
	ii. 1 730 × 1 100		Millet	33
	iii. 1 810 × 950		Fire wood	35

Table 4. Comparative Performance of Current Rural Vehicles on Full Capacities

Vehicle	Full load capacity (kg)	Speed range (km/h)	Haulage distance (km)	Advantage ratio over head (%)	Average load utilization factor (%)
Head	40-50	4-6	10	100	63
Pack animal	80-150	3-5	5	250	61
Bicycle carrier	80-100	10-15	25	500	53
Motor cycle carrier	150-200	30-60	40	4000	46

Source: Howe, 1983; Adeoti, 1988.

greater haulage distance. However, the head/portage was available for all and terrain unlimited. Also, bicycle and motorcycle riders need fair amount of skill to maintain equilibrium, especially when riding at full load.

In regular haulage, the average utilization factors were 61, 53, and 46% for animal, bicycle and motorcycle, respectively. The general under utilization was largely related to the commodity packaging method and individual vehicle configuration. Both bicycle and motorcycle carrier floor areas and supports were inadequate to sustain sufficient load with the existing packaging materials and methods without sustaining produce damage. Some of the above results did not include the 4-wheel vehicles type due to their low number in the interior rural area. Also, these vehicle owners/drivers did not wait for necessary measurements to be taken.

Observations and Conclusion

The above review, results and discussion so far indicate that there are variations in topography, road/route, trip length purpose good, etc. relating to transportation in the rural area. By far the most frequently undertaken trips were those related to farming and domestic needs and were short-distance trips. On the other hand, trips for social and religious purpose which were of long distances seemed almost insignificant in terms of frequency. However, because each travel purpose constituted invaluable role in the life of rural families, each class of trips are very important. In reality, different modes of transportation serve, characteristically, different movement demands and they infrequently are in direct competition. For example, while it is physically impossible for the 4-wheel motor vehicles to traverse terrain that a donkey would do with ease, it is arduous to use head/portage for a journey of 50 km or more. The above results indicate that a complex interaction exists between the examined travel parameters.

In conceptualizing the needed transport system to meet the needs of rural dwellers, one should consider the rural household requirements for all their travel purposes. Granted that there are no resource constraints, the most satisfactory solution would be to link all villages, farmlands, storage centers with all season feeder roads and each household to have access to suitable vehicles, but such proposal cannot be feasible for the foreseeable future, especially in the developing countries. It is also obvious that there cannot be a "vehicle" that will be appropriate to all households for all occasions. One of the strategies for meeting the rural travel needs must, therefore, be based on providing a graduated choice of transport system. In the interim and within the context of existing transport infrastructure, the choice includes the manual, animal and motorized systems which consist of head/portage, animal pack, bicycle motorcycle and the 4-wheel vehicles. The immediate potentials as well as limitations of each of these in meeting the identified rural travel needs are briefly outlined as follows:

Human Portage

This includes walking with head, shoulder or backload. The survey revealed that this was the most common mode. Its advantages include ready availability and ability to traverse steep, hilly or rocky terrain. However, human portage is arduous as the carrier has to support the whole load in addition to propelling it forward. It is also slow. It is, therefore, not surprising that it is the least efficient in term of load carrying capacity and speed (**Table 4**). Also human portage load decreases as travel distance increases and terrain becomes difficult. There is also the concern that habitual carrying of very heavy loads on head, shoulder or back can cause physical disabilities and injuries.

Animal Pack

The advantages of animal in rural transport include ability to traverse unlimited terrain as pack animal and has higher load carrying capacity than head/portage, bicycle, and motorcycle. Despite these advantages, the survey recorded very low ownership of animal for transport in a tse-tse fly area. This limited ownership of animal may not be unconnected with its low speed, limited potentials for usage in other activities due to none availability of implements, and difficulties in maintaining the animal, especially during the dry season. Moreover during the season when the route/farm road is narrowest due to overgrown weeds, animal traverses with great difficulty. This period coincides with the early part of farm harvest season when goods haulage is in high demand. It, therefore, seems that the role of animal in meeting rural transport needs can increase when higher proportion of households own animals, which seems realistic when these animals are engaged in other gainful activities in order to make them cost effective.

Bicycle and Motorcycle

Both bicycles and motorcycles in their 'two-dimensional' configuration have distinct advantages in rural transport as follows:

i) Both are the commonly-owned and used vehicles. The bicycles are the cheapest vehicle to own and maintain vis-á-vis of rural household income level. This enhances self-ownership as strongly desired by the rural households.

ii) Both have well established repair shops for proper maintenance barring shortage of spare parts.

iii) Both are versatile; they play multi-roles; business trips for goods and person trips; and family vehicle for social, religious and recreational activities.

iv) For short-distance trips forming over 75% of total trips and with average trip load requirement of less than 100 kg, the cycles can meet most, of the rural travel needs.

v) Being 'two-dimensional' and with relatively high clearance they fit into the existing routes throughout all season. However, being 'two dimensional' the rider needs a fair amount of skill to maintain equilibrium, especially when riding on full load.

The survey, however, reveals that bicycles and motorcycles were under-utilized partly due to their carrier configurations. Their carriers 'floor' areas are two small for mounting existing packaging devices. These limitations can be eliminated by modifying their carriers to suit the existing local packaging devices and methods.

Four-wheel-vehicles

The survey results indicate the needs for motorized vehicles other than the cycles for specific instances such as social, religious and marketing activities involving very long distant journeys; and bulk haulage of farm products. However, and as mentioned earlier, rural travels can be divided into two segments, namely; from the interior to the access/feeder roads; and from the feeder road to the market centers and villages/towns. The few identified 4-wheeled vehicles plied the latter segment. They were few, scarce, unreliable, especially in terms of timing; and the rural trip makers have to pay for their high costs of acquisition and maintenance. In view of the identified rural travel needs as well the household's economic levels; self-ownership of a 4-wheel vehicle which is ideal, would not be cost effective. Until access roads are provided, the choice and economy of this group of vehicles in rural transport cannot be certain.

In view of the rural travel needs and the existing transport infrastructures, the immediate challenge is in matching the two to meet at least part of the household travel needs. Under the prevailing rough and narrow routes, the 'two dimensional' vehicles, that is, the bicycles, motorcycles and their derivatives, have distinct advantage for real rural transportation. Also, their fixed and variable costs are low and in today's economy of skyrocketing fuel costs, these costs become significant. Essentially, the small vehicles of small unit of automatic power at correspondingly low level of capital cost are appropriate, especially in a low-wage economy such as the rural areas in developing countries. Other factors such as safety reliability and versatility which the cycles possess are equally significant.

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Mechanization of Sugarcane Production in Pakistan

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Abstract

Sugarcane is very important cash crop in Pakistan, but its yield per hectare is very low due to inadequate farming techniques and lack of versatile machines/implements for sugarcane cultivation. The AMRI Research Division, Faisalabad, designed and developed a sugarcane planter, a multipurpose interculture tool, a rotary weeder and a stubble shaver for performing various operations of sugarcane cultivation. The machines were used to perform various cultural practices such as planting, interculture, fertilizer application, earthing up, weed control and stubble shaving. These machines/implements have proved to be effective and multipurpose aid to the farmers, especially in the developing countries for increasing the yield of sugarcane crop substantially.

Introduction

Sugarcane is one the most important cash and foreign exchange earning crops in Pakistan. It plays an important and prime role in the sugar industry. In Pakistan almost 962.8 thousand ha is planted to sugarcane with an average yield of 46.1 t/ha (Agril. Statistics of Pakistan, 1993-04).

It has been estimated that the yield potential of sugarcane crop can be increased 2 to 3 times (compared to existing level) with the use of mechanized farming operations. Mechanization has become a necessity both to intensify production and increase the speed of operation. Mechanized planting and other cultural practices in sugarcane cultivation reduce sowing time, labor and cost. It also results in vigorous crop growth and development with more sugar recovery due to higher seed rate, proper sowing depth, brings about better crop stand and weed control. The sugarcane planter provides higher yield per ha by planting more sets per ha as compared to the indigenous method of planting (Yasin et al., 1988).

The germination of unwanted plants (weeds) in sugarcane crop hampers its growth by utilizing useful ingredients from the soil. These weeds compete with growing crops for moisture, soil nutrients and sunlight. The magnitude of yield reduction due to weeds varies widely and losses were not less than 15-30% under normal conditions. Makhdoom and Umer, 1986 reported that weed infestation reduced the numbers of millable stalks, their thickness and thus average cane yield. Besides reducing crop yield, weeds increase the difficulty of harvest, thus it is imperative to eradicate weeds.

One of the major reasons for low yield of sugarcane crop is its lodging feature which impedes its growth, lowers its sugar recovery and creates harvesting problems. Earthing up has been observed to help much in the control of soil erosion and develops fairly erect clumps of stalks (Agnihotri, 1965). Earthing up helps to reduce lodging, increase nutrient availability, develops sugarcane roots vigorously and establishes the plant well.

Most of the cane harvesting in

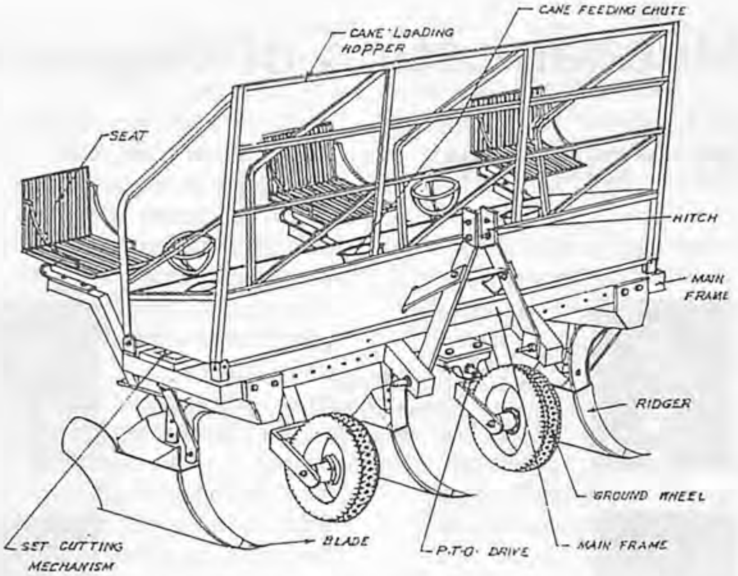

Fig. 1 Modified AMRI sugarcane planter.

Pakistan is done manually which is not done flush with the ground and, therefore, leaves 10-30 cm high stubbles in the field. This reduces sugar recovery of the canes and provides hiding places for stem borers. Furthermore, the sugarcane crop sown during September and February obtains stem borer infestation 6.28% and 9.23%, respectively, with cane yield of about 88 t/ha (Halimie et al., 1994). The larvae of the borers damage the crop by boring into roots, stems and tops of the cane. Thus they reduce cane weight up to 30-40% (Kalra and Sidhu, 1965). Borer damage also reduces juice quality (Cheema, 1953). Indiscriminate use of insecticides has created many serious problems. Cultural control is the oldest method of crop protection and a powerful tool of integrated pest management (Huffakar, 1980). The shaving of sugarcane ratoon crop with stubble shaver at appropriate depth below soil surface and at suitable time helped kill borers and developed the shoots better.

A rapidly growing plant needs a vigorous root system in order to obtain the necessary amount of moisture and soil nutrients. The roots of the tender shoot do not reach the soil too long and thus the shoots remain weak and unhealthy. For a good crop, the shoot portions should remain in the soil and not above the soil surface. The removal of apical buds of the stalk after harvest, produces new sprouting and helps early development of new shoots from the stubbles (Shrivastava et al., 1992). To achieve this effect faster shaving off or removing any stubble portion above ground surface should be done with in a period of two weeks after harvest.

The soil in between the crop rows should be loosen for inducing more early sprouts (Ricaud and Arceneaux, 1986). The shoots emerging from the lower portion of the stubbles were better than those arising from the upper portion in terms of stalk length, diameter and dry matter production (Miyahara and Kamiya, 1984). the shoots developed into vigorous canes when the stubbles were cut very close to the ground (Sharma and Singh, 1988).

The cultivation of sugarcane crop is more economical if more returns are obtained from the ratoon crop. Borden (1982) reported that about 4-5 ratoons were quite common in other cane growing countries of the world such as Brazil, Cuba, and India. On the contrary, in Pakistan, usually one ratoon crop is maintained with very low yield. One of the reasons for low yield is lack of mechanized cultivation practices for the ratoon crop. The ratoon crop has many advantages; it saves time and expenses which are otherwise incurred on seed bed preparation, it avoids expenditures for the procurement of seed, it ensures high sugar recovery and also enables early start of the sugar industry.

The seasonal and ratoon crop yields can be increased simply by performing various mechanized cultural practices in time. Some of the important mechanized cultural practices are mechanized planting, interculture, earthing up, fertilizing and stubble shaving. In order to mechanize various cultural practices for the sugarcane crop, the Research Division of AMRI at Faisalabad has designed and developed a set of implements/machinery for mechanized sugarcane production. These are a sugarcane planter, a rotary weeder, a disc ratooner and stubble shaver.

Description of the Implements

Sugarcane Planter

The sugarcane planter is to economize the intensive labor requirement for cane planting and increase the number of sets per hectare. The main parts of cane planter developed by AMRI are main frame, furrow openers, cane feeding chutes, set cutting mechanism, feeder seats, support wheels and hopper for storing of canes (**Fig. 1**). The machine is tractor-mounted and PTO driven. The tractor PTO speed (450 to 500 rpm) is reduced through gears to 100 to 110 rpm while a cam is used to drive the reciprocating cutters. The cutter return is through a set of springs. The cane stalks are fed vertically through feeding chutes which are suspended and spring loaded. The chutes provide support for effective and positive cutting of canes into sets of an average length of 455 mm. Below the chutes are metal plates called deflectors which are provided to divert and position the sets into the furrow. The planter opens the furrows, cut the sets and places them into the furrows properly.

After intensive testing, the planter was modified to increase its loading capacity by attaching ground supporting wheels. The capacity for storing the canes on planter was increased to 650 kg of detrashed cane. The cane feeding chutes were modified to avoid entangling of crooked canes. The deflector and set orientation plates were modified for accurate placing of sets into the furrows.

The planter is capable of planting 50 000-75 000 sets/ha at different tractor ground speeds whereas with manual planting only 45 000-50 000 sets/ha are achieved. The man-hour/ha required with this planter was almost 3 times less than the time required with manual planting (Yasin et al., 1988). The planting cost with this planter is US$36.80/ha, which is about 41.8% less than the manual planting cost of US$63.25/ha. The average field capacity of the planter is 0.50 ha/h and the approximate cost of production is US$1 200.

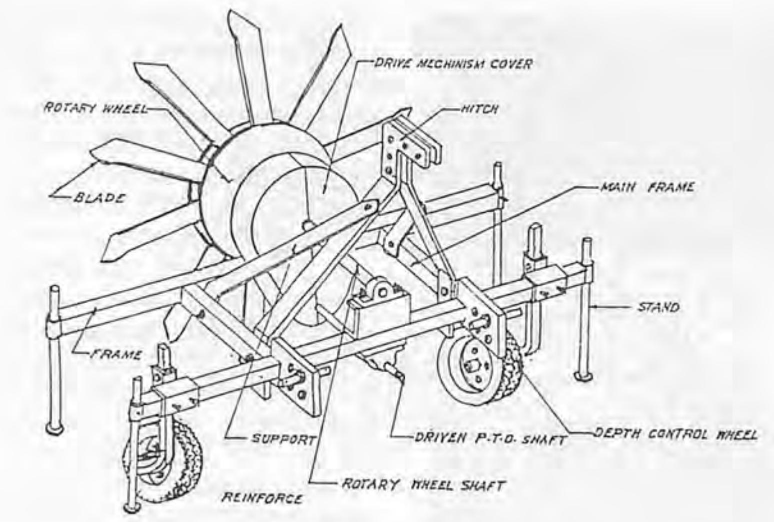

Fig. 2 Rotary weeder.

Rotary Weeder

The purpose of this implement is to eradicate weeds growing in between and around the sugarcane plants. It also produces pulverizing effect on the soil and thus increasing its water and air absorbing capacity. The rotary weeder is a tractor rear mounted PTO driven implement which has the following major components: main frame, power transmission, drive mechanism, rotor, cutter blades and depth wheels (**Fig. 2**). The drive mechanism consists of two gears operated by a chain which drives the rotor at 150 rpm. Its operating speed is about 4.8 km/h at first or second low gear with approximately 1 500 engine rpm. The rotor has 10 steel flat arms with sharpened edges to eradicate weeds and perform hoeing.

The main frame, 1 830 mm long, was developed from 50 × 50 × 6 mm M.S. angle with cross reinforcement of same size bars. The mast is composed of 75 × 19 mm M.S. flat bars. Ten arms (370 × 62 × 7 mm) of high carbon steel attached on rotor assembly are replaceable to which sharp and taper ends are attached. These blades are fixed in a pair of disc each 10 mm thick with 455 mm dia. The main shaft (275 mm and 45 mm dia) was used for transmitting power to gear assembly. The ground supporting wheels are also provided for uniform eradication of weeds. The total weight of the implement is about 1 40 kg and its approximately cost of production is US$500. The implement's field capacity is about 0.6 ha/h.

Multipurpose Interculture Tool (MIT)

This implement is used for interculture, earthing up and placement of fertilizer for sugarcane crop. It eradicates weeds from in between the rows and at the same time tills and moves the soil towards the plants, thus performs earthing up operation. The tractor-rear mounted MIT consists of main frame, disc gangs, fertilizer box and metering device with drive wheel (**Fig. 3**). This implement is 1 400 mm long, 1 175 mm high and 1 850 mm wide. The rectangular shaped main frame is composed of two boxes made from 65 × 62 × 7 mm thick M.S. angle. It has four disc gangs each containing 4 discs of 455 mm dia.

The disc penetration and the amount of soil moved for earthing up can be increased or decreased by changing the angles of discs through gang movement. Four sets each of four notched type discs with diameter of 455 mm and thickness 4 mm are mounted on the frame. The disc angle can be adjusted according to the nature of work. The adjustable, U-shape gang assembly is made from 6 mm thick M.S.

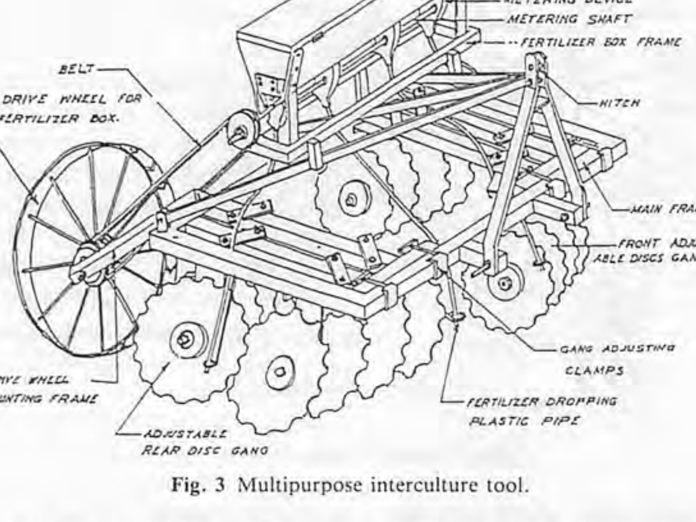

Fig. 3 Multipurpose interculture tool.

rolled channel of 100 × 50 mm while the square gang shaft is 29 × 29 mm of M.S.

A fertilizer metering mechanism was mounted on the multipurpose interculture tool for application of fertilizer. It applies fertilizer in a metered quantity uniformly. The MIT performs three operations, i.e., interculture, earthing up and fertilizing simultaneously. Its field capacity is 0.20-0.30 ha/h and the cost of the implement is approximately US$667.

Stubble Shaver

The manual shaving of sugarcane stubbles is time and labor consuming. The manual stubble shaving requires 20-25 man-day/ha. The tractor-rear mounted, PTO driven stubble shaver cuts/shaves the sugarcane stubbles close to or below the ground surface at uniform height. It also cuts the fog/mist affected tips of the stubbles and thus accelerates uniform sprouting. Furthermore the stubble shaver brings the neighboring soil to the same level which enhances its water absorbing capacity. The use of stubble shaver promotes sprouting of more plants from each stubble.

The stubble shaver developed by AMRI consists of: main frame, circular disc having blades, gear unit, cover and depth control skids. The shaving disc consist of L-shaped cutting blades (**Fig. 4**). The disc rotates at a speed of 350 rpm in 1st high gear with 1 800 rpm of tractor engine. The overall length, width and height of the implement is 1 600, 1 800 and 1 025 mm, respectively. The main frame is 1 780 × 50 × 50 mm M.S. square beam welded with two 585 × 50 × 50 mm M.S. square bars. The other parts are mast, skid shoe assembly, depth control lever and blade mounting assembly.

The blade mounting assembly consists of M.S. disc 590 mm diameter and 10 mm thickness. It has six L-shaped blades made of SAE 1 045 material 280 mm, long 100 mm wide and 7 mm thick with sharp edges. The rubber cover is attached with the cover plate to reduce dust spreading during operation. The field capacity of the machine is 0.2 ha/h and the cost is approximately US$834.

Sugarcane Harvester

There are three known types of sugarcane harvesters in the world: i.e., base cutter, whole stalk harvester and chopper harvester. The base cutter cuts the cane and leaves it on the ground for manual topping, detrashing and collection. The whole stalk harvester cuts the base and top while cleaning and collection is done manually.

The chopper harvester cuts the base, tops the cane and also performs detrashing cum-billeting and trailer loading. Two of the chopper harvesters (Austoft 6000 and Austoft 7000) have been tested in Pakistan (Farm Machinery Institute, 1987). After their evaluation, it was concluded that these could not be adapted until an integrated system is introduced.

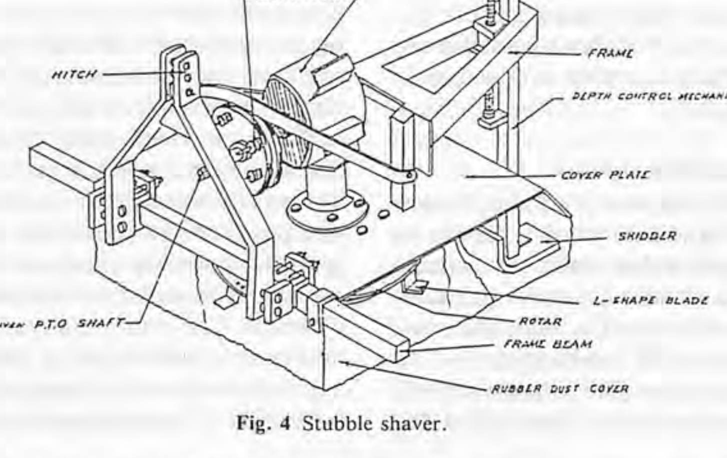

Fig. 4 Stubble shaver.

It has also been observed that only base cutters may prove successful in Pakistan. AMRI has started adaptation/modification of two types of fodder harvesters at Multan and Faisalabad. The units modified has been tested initially to harvest sugarcane and have shown encouraging results in terms of field performance and farmer's acceptability (Rehman and Khan, 1993).

Materials and Methods

The sugarcane planter was designed and fabricated at AMRI Research Division, Faisalabad. The rotary weeder, stubble shaver and multipurpose interculture tool were adopted from Bonel (Australia) with some modifications. These modifications were done to improve their work performance and match them according to local farm and farmers' conditions. The available workshop facilities and manufacturing technologies were utilized in the fabrication of these machines at AMRI Research Division, Faisalabad. The materials were procured from the local market and specific materials were used for fabricating some critical parts such as cutting blades, gear units and cutter tines.

The machines were tested initially in the field at the Machinery Demonstration Unit (MDU) Farm of AMRI at Faisalabad. Keeping in view the preliminary test results, improvements were incorporated in the machines/implements. The improved machines/implements were sent to the field for testing and evaluation. The machine/ implements are being demonstrated at farmer's fields for their adoption.

Results and Discussion

The package of machines/ implements developed for sugarcane crop was tested at MDU Farm, Ayub Agriculture Research Institute (AARI) Sugarcane Farm and farmers' fields to check the performance and durability of the implements. The test results, suggestions and comments of the farmers and experts about performance of the implements were recorded and useful alterations were made accordingly.

The rotary weeder was tested in the field (**Fig. 5**). It eradicated approximately 60-70% of the weeds in between and around the sugarcane plants. The average field capacity was approximately 0.6 ha/h. At least 12 man-day/ha were saved for interculture in between and around the plants of the same fields. Thus, the use of rotary weeder cut down labor, saved money and time.

The multipurpose interculture tool (MIT) performed all the three operations; i.e., interculture, earthing up and placing of fertilizer simultaneously at the rate of 0.2 ha/h whereas 18 man-day/ha were required for manually carrying out these cultural practices. The use of MIT resulted in saving of US$85/ha over the manual operation. The MIT was tested at the Sugarcane Research Institute Farm and MDU Farm, Faisalabad (**Fig. 6**). Favorable results were obtained.

The stubble shaver was tested and it was observed to shave the stubbles uniformly with an average field capacity of 0.2 ha/h as compared to manual work which took about 25 man-day/ha. It was tested in the areas situated close to the Sugar Mills for its quick adaptability (**Fig. 7**). The performance of the implement was much appreciated by the farmers and experts from sugar mills. The stubble shaving of sugar cane with this machine gave 33% less cost as compared to the manual method.

The sugarcane planter planted 62 000 sets/ha with an average field capacity of 0.5 ha/h (**Fig. 8**). The planting of sugarcane sets with this machine saved US$ 26.5/ha as compared to manual planting. The performance of the planter was highly appreciated by the farmers and local manufacturers. Its manufacture has since been started by the local industry.

Fig. 5 Rotary weeder in action eradicating weeds in between the sugarcane plants.

Fig. 6 The multipurpose interculture tool in use to interculture in between the cane rows.

Fig. 7 Shaving of sugarcane stubbles with the stubble shaver.

Fig. 8 Sugarcane planter at work in the field.

Summary

The machines/implements developed for mechanized cultivation of sugarcane crop were: a sugarcane planter, multipurpose interculture tool (MIT); a rotary weeder and a stubble shaver. These machines/implements were designed and fabricated at the Research Workshop, AMRI Division, Faisalabad. The workshop facilities, manufacturing technologies and locally available materials were used in fabricating these machines/implements which were tested in the field for cane planting, interculture, fertilizer application, earthing up and stubble shaving. The performance of the machines/implements was found satisfactory. The local manufacture of the sugarcane planter and disc ratooner has since been started.

The cane planter planted 62 000 sets/ha as compared to manual planting of 45 000 sets/ha. It saved 80 man-h/ha otherwise required for set cutting and resulted in 41.8% less planting cost than that of the manual planting method. The interculture, earthing up and fertilizing operations were simultaneously performed with the MIT. The field capacity of this tool was 0.25 ha/h.

The rotary weeder eradicated weeds efficiently and pulverized the soil in between and around the cane plants. Its field capacity was approximately 0.6 ha/h. The stubble shaver cut the stubbles and helped to kill stem borers which in turn resulted in vigorous and uniform sprouting and development of the shoots. The field capacity of the stubble shaver was approximately 0.2 ha/h.

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Mechanization Level in Vegetable Production in Antalya Region and Turkey

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Abstract

Agricultural mechanization that provides the use of modern technologies in agriculture make better living and working conditions in rural areas and increases working capacity and yield. The agricultural mechanization level of a country is determined in terms of kW/ha, ha/tractor, number of tractors/1 000 ha, mechanical power/total power, equipment weight/tractor or numbers of equipment/tractor. According to the 1994 agricultural mechanization level in Turkey, that is 1.73 kW/ha, is higher than the world average. The average power of the tractor mainly used in agriculture is 40.6 kW. This shows that most of the tractors used in Turkey are big-sized. The rate of low-powered tractor that is available for vegetable crop production is 2.8% of the total number of tractors in the country. All steps in field crops production are almost mechanized except thinning and harvesting of some crops such as cotton. Whereas vegetable production is commonly done by human labour except tillage and spraying. Vegetables are intensively produced in the south and west coast of Turkey.

A survey was carried out to determine problems of vegetable production holdings in Antalya which is in the south coastal part of the country. The holdings in Antalya are small, average 4.8 ha. The average tractor power in Turkey and Antalya are 40.6 kW and 36.7 kW, respectively. Most of the agricultural machineries are suitable for field crops production even as the tractor power is high. A variety of machineries used for agricultural production are low in power. Problems in sowing and transplanting are among the problems in vegetable production. The problems are labor shortage and damage to seedlings during transplanting. Spraying is fully mechanized followed by tillage.

Introduction

Turkey is a developing country. It is mainly agriculture-based economy. The share of agriculture in the Gross National Product (GNP) is 17%. Some 45% of the total active population is employed in agriculture. However, this rate decreases year by year. The share of agriculture in total export today is about 20%.

Land usage status in Turkey in 1990 is shown in **Table 1** which shows that the total arable land is about 28.5 million ha. About 36% of the total land area is suitable for agriculture. About 25.9% and 27.9% are forestry and fodder land-range, respectively (Anonymous, 1992).

Turkey has nine agricultural regions with different climates, hence a large variation in the crops produced. Turkey has a great potential for Mediterranean crops such as fruits, vegetable, citrus and continental crops such as cotton, cereals and tobacco. The types of soil and agroclimatic zones in Turkey provide favorable conditions to grow subtropical crops such as banana, kiwi and ananas. In addition, there are many glasshouses and plastic tunnels in the coastal regions.

The percentage distribution of

Table 1. Land Usage Status in Turkey

Land Use	1 000 ha	Percent
Agriculture	28 479	36.50
Fodder land and range	21 745	27.90
Forestry	20 199	25.90
Other	7 522	9.70
Total	77 945	100.00

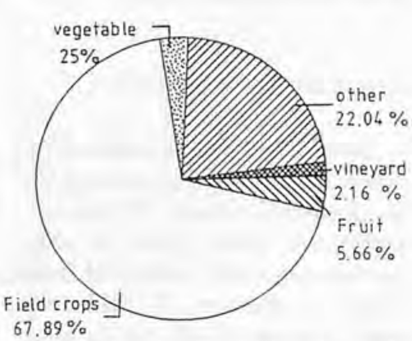

Fig. 1 Percentage distribution of agricultural land in Turkey.

agricultural lands in Turkey, according to the 1992 Agricultural Statistics, is given in **Fig. 1**.

Refering to **Fig. 1**, 67.89% of the total agricultural land was used for field crops and vegetable production. Vineyards and some fruit trees cover 2.25%, 2.16% and 5.66% of the total arable land, respectively.

The total vegetable production area in Turkey is 610 000 ha and approximately 15.5 million t of vegetable are produced annually in this area. Turkey ranks fourth in the world vegetable production. Vegetable production is intensive in the west and south coastal regions, i.e., the Aegean, Marmara and Mediterranean. Some 66.7% of total vegetable production in Turkey comes from these regions. Antalya in the Mediterranean Region has a vegetable production area of 25 000 ha. Vegetable production area in Antalya increases year by year which is faster than other parts of the country. This fast increment will be higher after the Southern Anatolia Project (GAP) will have been completed. After GAP project, total irrigable area in Turkey will increase by about 2 million ha and will reach about 5 million ha. According to the agricultural development planning of the Turkish Government, field crops will be mainly grown in the GAP Region. The coast areas of Mediterranean are expected to grow horticultural crops.

Areas of Mechanization

Some 77% of the total farm power in Turkey is represented by mechanical power (Özmerzi, 1990). A large part of this mechanical power is used for field crops production. A relatively small portion of this rate is used in vegetable production. This is because transplanting, planting, harvesting and cultivation of vegetables are still carried out by human power. That of tillage, direct sowing, irrigation and spraying use mechanical power.

Equipment such as plough, disc harrow, cultivator and rotary tiller used for tillage are usually for field crops production. Horse plough, though very few, is still used in some of the rough and small land areas and in small holdings.

Industrial vegetable crops are directly sown with the use of machines. Over the last few years, planters have been developed more by the domestic manufacturers. Therefore, the use of these machines increase day by day even as the use of transplanters is limited and these machines are used to plant bare-root seedlings such as tobacco and cabbage on small-sized farms and research institutes. Potting machines that reduce planting errors and prevent weak crop growth are still not used in Turkey.

In irrigation, only water can be transported from source to the irrigated areas using power-driven pumps. Furrow irrigation is a traditional system mainly in irrigated vegetable crops. Sprinkler system and trickle irrigation are mainly used for crops grown in some modern holdings that implement new technologies.

The spraying equipment for the application of herbicides, insecticides and fungicides to protect vegetable crops are popular in the country. Otherwise, most of the other agricultural operations are completely performed by hand.

Extent of Agricultural Mechanization in Turkey

Agricultural mechanization was first introduced in the country in the 1860s in order to increase cotton production. After the declaration of the Turkish Republic in 1923 attempts were made to use modern technologies in Turkish agriculture. During these years many agricultural machines and equipment were imported **(Table 2)**.

After 1960, the number of imported agricultural machinery and equipment decreased as the production of some machineries was started by local manufacturers. The first mass production of tractors started in 1955. After the 1960s agricultural mechanization developed very fast. While the number of tractors in 1974 was 200 000 units, this number exceeded 800 000 in 1993. Seven local companies in 1978 manufactured

Table 2. Weight of Imported Agricultural Machineries and Equipment (Unit: mt)

Year	Weight
1923	1 324
1927	4 750
1940	2 986
1950	30 000
1960	7 000

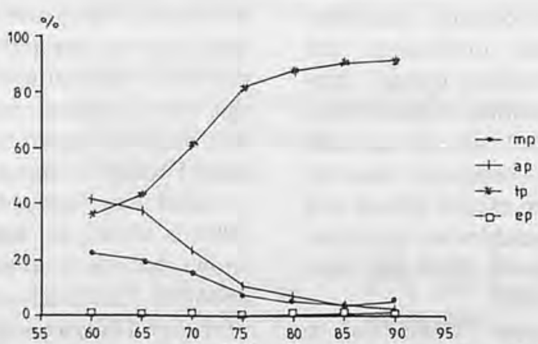

Fig. 2 Distribution of power sources used in Turkish agriculture.

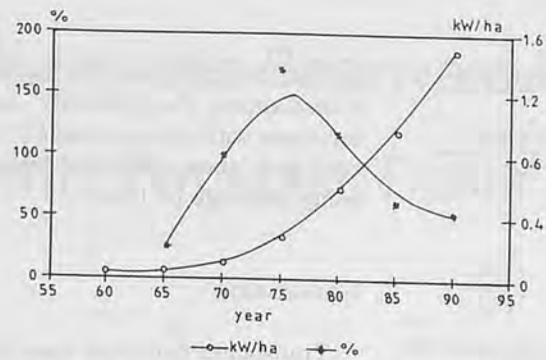

Fig. 3 Change in increment of mechanization level.

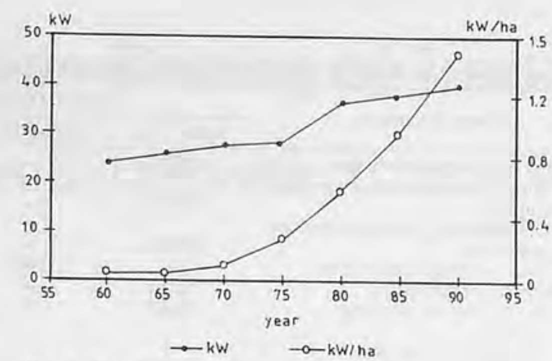

Fig. 4 Change in average tractor power.

Table 3. Mechanization Level and Distribution of Power Group of Tractors in Antalya and Turkey*

Tractor power (kW)	Distribution (%)	
	Turkey	Antalya
<25	2.8	6.4
25.8-35.8	26.4	57.7
36.8<	70.8	35.9
Average	39.8	36.7
kW/ha	1.48	3.90
Equipment number per tractor	5.26	5.25

12 different tractors, five companies in 1992 manufactured 24 different tractors in terms of type and power (Sabancı and Akıncı, 1994). Total tractor numbers, together with imported ones, was 32 500 in 1978, the number decreased to 24 519 in 1992 because of the market was saturated.

At present, tractor power use has increased while man and horse power use decreased. The use of electricity in agriculture is still very low and is limited to lighting and electric devices. As shown in **Fig. 2**, the use of tractor power is about 90% (Zeren and Isık, 1991).

Fig. 3 indicates mechanization level based on years and change of mechanization level. Mechanization level as tractor power (kW) per ha increased year by year. A fast increment in change of mechanization level in 1975 year reached 170%.

Fig. 4 shows the average tractor power by years, constantly increasing between 1970 and 1990.

Tractors use in the country are mainly high powered, the average being 39.8 kW (**Table 3**).

As shown in **Table 3** distribution of tractor power in Turkey is concentrated on over 35.8 kW (70.8%). Small-sized tractors up to 25 kW used in horticulture is 2.8% of total tractor number. There is a similar status in Antalya region where 6.39% of the total vegetable production takes place (Özmerzi et al., 1992). Tractors used in Antalya are mainly medium and high powered.

Mechanization Status in Vegetable Farms in Antalya

A survey was carried out to determine the mechanization characteristics and problems of vegetable production holdings in Antalya. The survey data were brought together from holdings randomly selected. According to the study, 61.69% and 18.31% of vegetable production areas were for field vegetable crops and cover crops, respectively.

The farms are generally small and their sizes range between 0.07 ha and 23 ha. The average holding is 4.81 ha in Antalya where the vegetable areas is 0.97 ha, and the share of vegetable production area in the total agricultural production area of the farms is 19.6%. The farmers generally grow vegetables in small-sized farms and field crops in the large-sized farms. The average working person number per family for a farm is 3.72. The average mechanization level of the farms is 3.90 kW/ha in Antalya higher than both in Turkey and the world's average. Mechaniza-

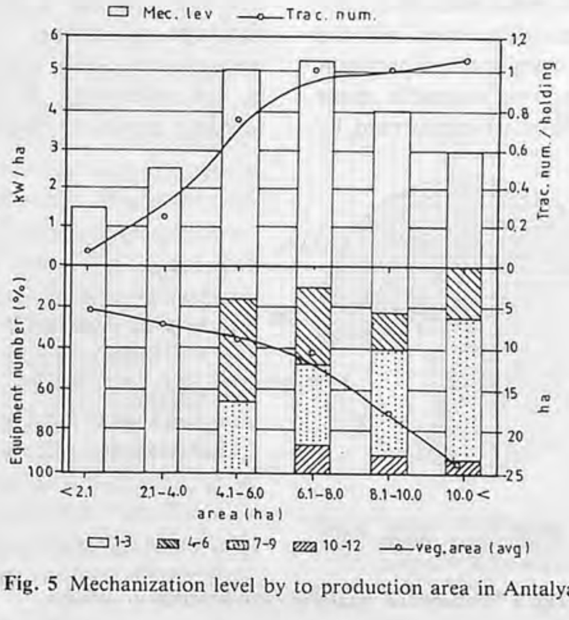

Fig. 5 Mechanization level by to production area in Antalya.

Table 4. Power Use Ratio of Farms in Vegetable Production, by Farm Operation

Farm Operation	Percent Distribution		
	Manpower	Animal Power	Mchines
1. Hot bed preparation seed sowing	100.00	—	—
2. Filling in plastic pots by prepping compost	100.00	—	—
3. Transplanting from hot bed to plastic pots	100.00	—	—
4. Tillage of production area	—	14.9	85.06
5. Seedbed preparation	52.61	—	47.39
6. Sowing or transplanting	98.07	—	1.30
7. Irrigation			
- drawing from source	—		100.00
- irrigation of field	99.34		0.66
8. Fertilizer application	87.66		12.34
9. Spraying	—	—	100.00
10. Weed control	96.75	—	3.25
11. Harvesting	100.00	—	—

tion level ranges between 1.46 and 5.35 kW/ha. As agricultural production area increased, mechanization level firstly increased and then decreased (**Fig. 5**). Agricultural tractor number per holding increased with the increase in the agricultural area.

During the crop growing period, power use in vegetable production was determined for each of the farm operations such as planting, irrigation, harvesting, etc. Mechanical power use needed for modern agriculture centers on tillage and spraying. Moreover, irrigation water is drawn from sources entirely using mechanical power such as electricity or internal combustion engines.

Horse power is used in the tillage of small greenhouse that cannot be tilled by tractor. All the operations from hot bed preparation to tillage in vegetable areas and harvesting are performed by manpower. The use of the least machinery are sowing or transplanting. Machinery in sowing is only used for direct drilling of crop seeds such as onion, melon and water melon that are grown in large areas. Transplanting is completely carried out by manpower. Greater manpower labor is required in transplanting and harvesting.

Problems in Vegetable Production

The problems in vegetable production in Antalya are indicated in **Fig. 6**, i.e., sowing and transplanting. The main problems were lack of labor, seedling damage during transplanting, shortage of proper sowing or transplanting time and difficulty in transplanting. Most of the seedling mortality occur especially after tansplanting. During the transplanting the mortality rate increases with the increase of the area and labor, the main reason being shortage of labor.

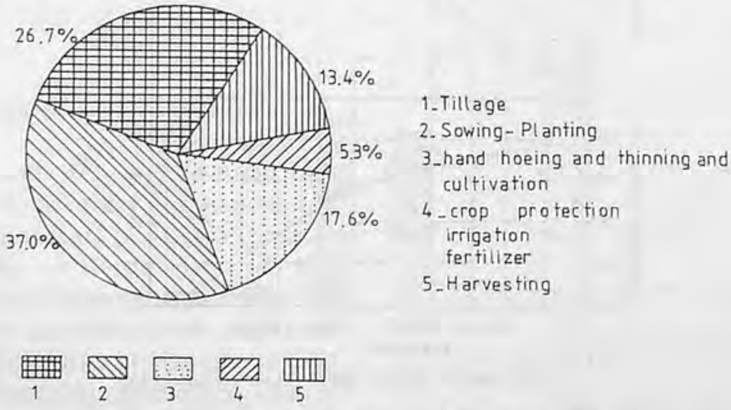

Fig. 6 Problems of vegetable farm holdings in Antalya.

Conclusion

Transplanting is more essential than direct sowing because much of vegetables grown in Turkey are transplanted. Mechanization in vegetable production is required from transplanting to harvesting for continuation of the increment in the production area. In addition, seedling production should be established for uniform and healthy seedling.

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Automatic Backward Motion Steering of Tractor with Two-axle Trailer Combination

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Abstract

Backing up of a tractor with a two-axle trailer, especially in a steered position, is difficult. Likewise to go back on a curve with a fixed steering-angle is impossible. The steering ability of the combination was increased by using the facilitating system which has cross-arms. But in order for this system to be applied to a combination, the trailer-hitch must consist of two pieces. Moreover, this system is not suitable and has to be pulled out when the combination is in forward motion. The combination can be steered automatically in every position by means of a system consisting of hydraulic and electronic units. And for this, axles of the trailer have to be steerable together. The trailer-hitch does not have to be rigidly tied to the front-axle of the trailer.

Introduction

To go back with a tractor together with a two-axle trailer is difficult. Even going back on a straight line needs more experiments in steering for drivers. The cause of this difficulty is that the steering angle of the trailer depends on the steered-motion of the tractor more than on a steering-angle of the tractor (**Fig. 1**).

When the combination is in backward motion in a steered position, the tractor and the trailer go to the same direction. However, turning centers are different from each other as well as turning radia. In this case, the steering-ability of the combination is limited. Moreover, to manoeuvre the combination in a short distance is impossible because, to steer the trailer needs to go back some more. There is another factor which limits the steering of the trailer, i.e., the tractor and the trailer are steered through opposite directions in the same position. When the combination is in backward motion on a straight line, if the tractor is steered through a direction, the trailer begins to steer continuously (the trailer does not go with a fixed steering angle). While the trailer is in a steered position, if it is required to steer to the opposite direction, steering angle changes in two different ways. When the tractor is steered to the opposite direction, if the angle C (C is between hitch-axis and the line which passes through the drawbar-pin and minimum-turning-center of the tractor) is an obtuse angle, the tractor forces the hitch to move to the other direction (opposite to the steered one). But, if angle C is an acute one, at first, the hitch is forced to move through first direction and, the motion of the tractor widens the angle C. The hitch then moves to the other direction (just as the tractor does). Due to steering, the hitch can touch to the rear-wheel of the tractor and, the combination cannot move. Therefore, to steer the trailer more than B_{cir} is not possible. The steering angle B reaches its critical value (B_{cir}) when the angle C is right angle (**Fig. 2**).

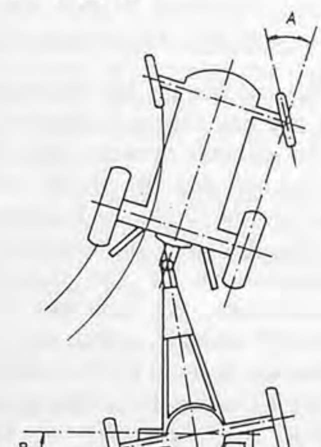

Fig. 1 Steering angles and in backward motion steering directions in a tractor with a two-axle trailer combination.

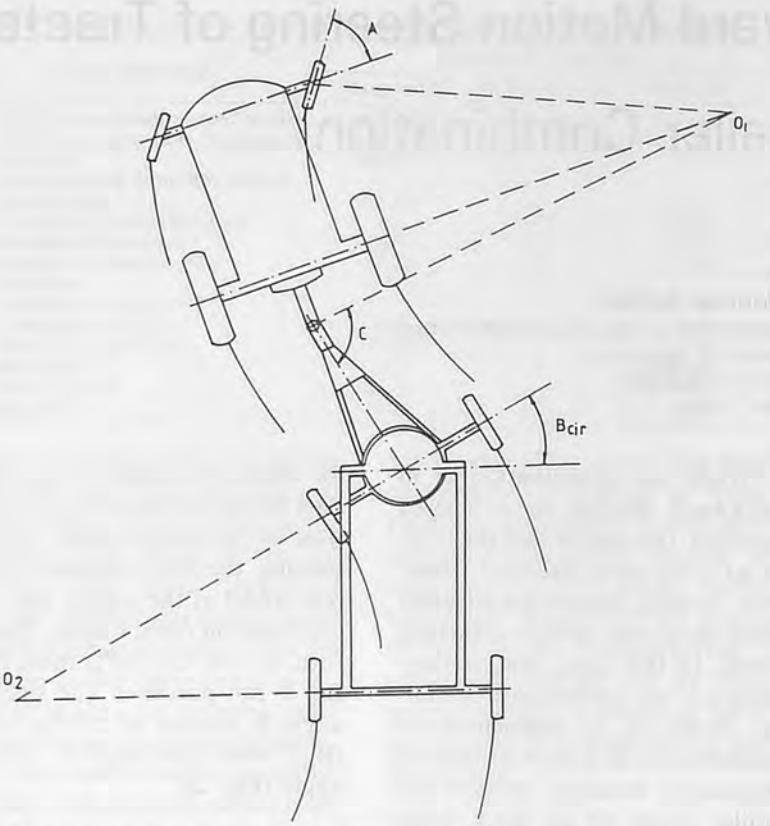

Fig. 2 Occurrence of the B_{cir} when the combination is in backward steering position.

The experiment has indicated that B_{cir} has changed depending on the distance between axles of the tractor and the trailer, the length of the hitch, the length of the drawbar and on minimum-turning-radius of the tractor. Nevertheless, B_{cir} changes between 20° and 30°, so that this situation can account for the limited ability in steering the combination.

The steering-ability of the trailer in backing up can be increased by means of auxiliary systems which increases the control of the driver. If the backward motion of the tractor can be transmitted to the steering-axle (front-axle) of the trailer directly, then backing up with a trailer would be easy.

Facilitating the backing up in a tractor/two-axle trailer combination depends on overcoming or on removing entirely two difficulties which are: 1) Non-linear relationship between steering angles of the tractor and the trailer; 2) The limited-ability in steering in backward motion. Backing up can be made easy by means of different mechanisms. Trailers which are axle-steered or wheel-steered require different facilitating systems. In this paper, the facilitating system with cross-arms for axle-steered-trailers is described.

Facilitating System with Cross-arms

This system refers to the use of cross-arms (**Fig. 3**).

In order to use this system in a combination, the tractor must have a modified drawbar (**Fig. 3**) and the trailer-hitch has to be adjustable (**Fig. 4**).

If the front-axle of the trailer is steered by the cross-arms, then the trailer-hitch may prevent the turning motion. To avoid this, the hitch has to consist of two pieces

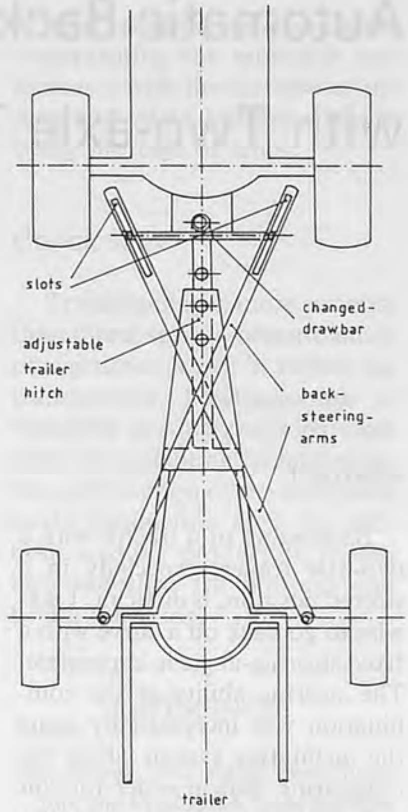

Fig. 3 Facilitating the system with cross-arms.

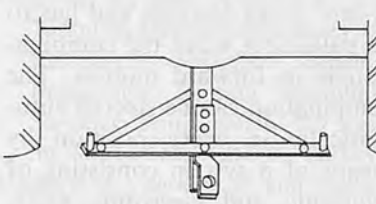

Fig. 4 The modified drawbar.

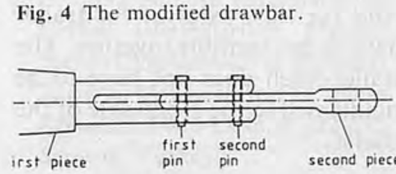

Fig. 5 The adjustable trailer-hitch.

Fig. 6 Connecting the cross-arms to the trailer.

so that it can transmit the hitching-power to the trailer in different ways. As for the crossing of the cross-arms (back steering arms), it is a requirement for steering the trailer in the same direction together with the tractor.

Operation of the Facilitating System

When the connections of the back steering arms are made to the tractor and the trailer, the steered-motion of the tractor affects the front-axle of the trailer linearly in the backward motion. The hitching force for the trailer is transmitted to the trailer in a non-linear way (adjusted hitch). The hitching force is applied to the trailer both from the back steering arms and the adjustable hitch.

When the tractor has been steered, one of the arms will force the front-axle of the trailer and the trailer to turn. In this position, the combination could have gone a little (not far). The combination could have been brought to the first position again by moving forward. But to go further forward or backward with the combination in a steered position is impossible. This is because the turning centers (in steering) of the tractor and the trailer have become different from each other. The vehicles are now far from each other. The adjusted hitch could not permit this kind of motion. Moreover, this system has not been suitable in forward motion because the trailer has been steered to the opposite direction from that of the tractor when the combination is in a forward motion.

The Automatic Steering System

The studies in steering of the combination have indicated that, to move the tractor and the trailer around the same turning center is a requirement for a real steering the combination on a curve. To accomplish this is impossible due to the structure because the steering angle of the trailer is variable in time although the steering angle of the tractor is fixed. Trailers are steered by means of their front-axles only. If they can be steered from their front and rear-axle together, the combination can move around the same center in the backward or forward motion (**Fig. 7**). Moreover, the trailer can be steered depending on the steering angle of the tractor by using an electro-hydraulic system. The amount of the steering angle of the tractor can be transformed to the electrical data by means of a potantiometer and, a hydraulic valve can control the oil-flow for the cylinder (actuator). Two actuators and two valves for steering-axles of the trailer are needed because the steering rates of axles are different.

In order for this system to be applied to a combination, the trailer-hitch has to be fastened rigidly to the body of the trailer (not to the front-axle). The electrical-current can be provided from the battery of the tractor and hydraulic liquid can be supplied from tractor hydraulic system. The steering rod of the tractor can give data for steering the trailer. The data can be improved by means of a timer for controlling the valves.

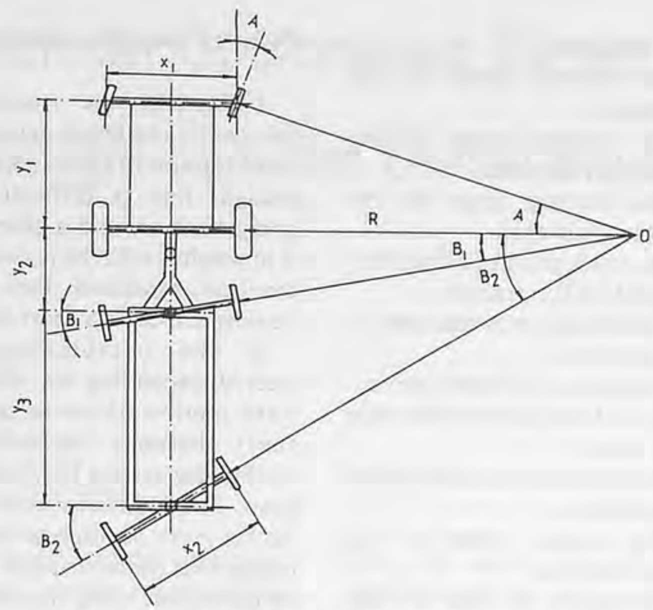

Fig. 7 Two-axle-steered trailer and tractor in steering.

The relations between steering angles of the tractor and the trailer can be written as following by means of **Fig. 7**:

$$\tan A = \frac{y_1}{R},$$

$$\tan B_1 = \frac{y_2}{R + (x_1/2)} \quad \text{and}$$

$$\tan B_2 = \frac{y_2 + y_3}{R + (x_1/2)}$$

$$R = \frac{y_1}{\tan A}$$

$$= \frac{y_2}{\tan B_1} - \frac{x_1}{2}$$

$$= \frac{y_2 + y_3}{\tan B_2} - \frac{x_1}{2}$$

$$\tan B_1 = \frac{\tan A(2y_2 - x_1 \cdot \tan B_1)}{2 \cdot y_1} \quad \ldots 1$$

$$\tan B_2 = \frac{\tan A(2y_2 + 2y_3 - x_1 \cdot \tan B_2)}{2 \cdot y_1} \quad \ldots 2$$

In the formula:

A : The steering angle of the tractor,

B_1 : The steering angle of the trailer-front-axle,

B_2 : The steering angle of the trailer-rear-axle,

R : The turning radius of the rear-wheel of the tractor,

y_1 : The distance between axles of the tractor,

y_2 : The distance between the tractor and the trailer (from axle to axle),

y_3 : The distance between axles of the trailer,

O : The turning center of the combination,

x_1 : The length of axles of the tractor (lengthes are equal),

x_2 : The length of axles of the trailer (lengthes are equal).

Steering rates of the axle of the trailer can be determined by electrical data (given by potantiometer) and by the actuators. Moreover, this system can be considered as a new design for steering the combinations in the future.

Results and Discussion

1. Steering the tractor/two-axle trailer combination in a backward motion or, even going on a straight line is difficult. Even going back around a sharp bend is impossible with the present combination. Moreover, they cannot be steered even in a short distance.

2. The combination was steered depending on the backward motion of the tractor in a short distance by using the facilitating system i.e., the cross-arms. But this system is not suitable for every position of the combination as the cross-arms have to be pulled out when the combination is in forward motion. Consequently, this system is suitable for moving around a sharp bend only a little.

3. In order to steer the combination automatically, the trailer must have a steerable-axles. One-axle steer trailers are not suitable. For this reason, it is necessary to modify the trailer with an automatic steering.

4. An electro-hydraulic system can accomplish the steering in the combination. By means of this system, the linear relation between steering angles of the tractor and the trailer can be accomplished easily.

5. To apply this system to the combination requires changes in structure and additional expenses. Moreover, the system is not recommended as it can be a dangerous combination.

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Experimental Research on Cottonseed Oil as Alternative Fuel for Single-cylinder Diesel Engine

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Abstract

The experiments were made on a S195 type diesel engine to determine the relationship between four working parameters (Intake-valve-closing angle, α; Exhaust-valve-opening angle, β; Fuel-delivering angle, θ; and Injection pressure, P) and specific fuel consumption in two working conditions of the engine when a blend of 30% cottonseed oil and 70% No.0 diesel oil was used as the diesel fuel. By means of optimization technique, the optimum working parameters for the two working conditions of the engine using the mixture of cottonseed oil and No.0 diesel oil were selected. Methods and problems in using cottonseed oil as a diesel engine fuel are discussed towards the end of this paper.

Introduction

Modern agriculture is dependent upon diesel engine. Traditional sources of diesel fuel for agriculture have been under threat from cost escalations, quality deterioration and supply disruptions. In the Peoples' Republic of China (PRC), with the rapid development of farm production and rural enterprise, the contradiction in rural energy between supply and need has became critical lately. Therefore, it is necessary to research alternative fuel and emergency fuel for self-supply of farm diesel engine to make up for the inadequate supply of petroleum. In the cotton-planted areas, it is possible to use cottonseed oil and its blend with diesel fuel as alternative fuel of diesel engine instead of pure diesel oil. In the past, it was used as a main cooking oil but now seldom used for some well-known reasons.

Considering the technology angle, cottonseed oil and its blend with diesel oil can be used as alternative fuel of diesel engines because their performance and characteristics are basically similar to pure diesel oil because of which a lot of researches have been conducted by Guangyi (1987), Yarbrough (1982), Goering (1981) and Yuanrong and Boyuan (1986). However, there is a certain difference between cottonseed oil and diesel oil in spraying characteristics and combustibility. Therefore, when the blend of cottonseed oil and diesel oil is used in the engine, the working parameters of the engine adjusted for diesel oil cannot make the engine keep the highest thermal efficiency which results in lower power output and high fuel consumption. In addition, the carbon deposit in the chamber and the contaminant in the crankcase lubricating oil will increase. Therefore, the working parameters should be readjusted in order to obtain the highest thermal efficiency.

Objective

The objective of the study is to obtain the optimum working parameters and their optimal combinations when the engine burns the blend of cottonseed oil and diesel oil based on the experiments with the help of optimum technology.

Materials and Methods

Experiment Equipment

All engine test works were run with a single cylinder diesel—S195 type diesel which is the main farm power in PRC. Its main parameters are shown in **Table 1**.

No.0 diesel oil and cottonseed oil purchased from the market were selected for the engine's performance tests.

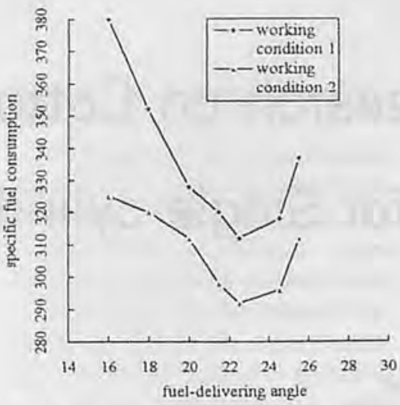
Test Methods

A. Evaluation Index

Tests were conducted to determine the power output, fuel

Table 1. Main Parameters for S195 Type Diesel Engine

Type:	S195
Manufacturer:	Zhejiang Lisui power plant
Model:	4-cycle, single cylinder, horizontal, water cooling
Type of chamber:	Swirl chamber
Cylinder bore/stroke (mm/mm):	95/115
Compression ratio:	20:1
Rated power/rated speed (kW/rpm):	8.82/2 000
Maximum power/ speed (kW/rpm):	9.70/2 000
Injection pressure ($\times 10^4$Pa):	1 226.25 ± 49.05
Fuel-delivering angle (degree):	Before upper dead centre 16-20
Method of start:	Manual start



Fuel-delivering angle, θ	Working condition 1	Working condition 2
16.0	380	325
18.0	352	320
20.0	328	312
21.5	320	298
22.5	312	292
24.5	318	296
25.5	337	312

Fig. 1 Relationship between fuel-delivering angle θ and specific fuel consumption g_e.

consumption, brake thermal efficiency and exhaust smoke. In the study, the evaluation index of diesel engine burning blend of cottonseed oil and No.0 diesel oil is mainly thermal efficiency, η_e. The relationship between brake thermal efficiency η_e and specific fuel consumption g_e is as follows:

$$g_e = \frac{3.6}{\eta_e H_u} \times 10^6 \qquad (1)$$

where H_u (low calorific value) is constant for the same fuel. For convenience sake, we can use the specific fuel consumption (g_e) to stand for the brake thermal efficiency η_e, that is the decrease in specific fuel consumption can reflect the increase in brake thermal efficiency. Therefore, in the following tests, the specific fuel consumption g_e was used as the main evaluation index.

B. Tests of Single Variable and Quadratic Regressive Orthogonal Design

In order to determine the relationship betwen adjustable working parameters of the engine and specific fuel consumption, and obtain the optimal combinations in two typical working conditions of the engine when a blend of 30% cottonseed oil and 70% No.0 diesel oil is used as a diesel fuel, a series of tests, including fuel-delivering angle of single variable and quadratic regressive orthogonal design of four factors were conducted.

Experiment Results and Analysis

Single Variable Test of Fuel-delivering Angle

The fuel-delivering angle of the S195 type diesel is 16-20 degrees before upper dead centre, 18 ± 0.5 degree is the optimum value when the engine is burning No.0 pure diesel oil. But for the alternative fuel, the optimum value is different. The relationship between fuel-delivering angle and specific fuel consumption obtained from the single variable test in the two conditions of 7.35 kW and 8.82 kW at 2 000 rpm is shown in **Fig. 1**. From the data of single variable test (**Fig. 1**), the optimal fuel-delivering angles under the two working conditions are all about 22 degrees.

The Quadratic Regressive Orthogonal Test

The quadratic regressive orthogonal design method (Shisong 1986) was adopted to determine the main adjustable working parameters influencing the brake thermal efficiency and to obtain the optimal combinations of the working parameters when the blend of 30% cottonseed oil and 70% No.0 diesel oil was used. The two test working conditions were a. Working condition 1: 7.35 kW/2 000 rpm; and b. Working condition 2: 8.82 kW/2 000 rpm.

Four working parameters of the engine (X_1: Intake-valve-closing angle, α; X_2: Exhaust-valve-opening angle, β; X_3: Fuel-delivering angle, θ; X_4: Injection pressure, P (unit: $\times$ 10 P^4) were arranged in the tests (**Table 2**). Prior to each test, the fuel injector was removed and cleaned of all carbon deposits. The engine run for 0.5 to 1 h to attain stable rated speed and torque. After each test was over, the working parameters were readjusted according to the test arrangement (**Table 3**).

After the significant test on regression coefficients and regression formulas, the equations of the four working parameters to specific fuel consumption under the two working conditions can be written as follows:

a. Working Condition 1

$$g_{e1} = 1\,264.029 - 8.365\alpha - 8.476\beta - 22.335\theta - 0.549P + 0.0898\alpha\beta + 0.2215\alpha\theta + 0.2295\beta\theta + 2.1207 \times 10^{-4}P^2 \qquad (2)$$

b. Working Condition 2

$$g_{e2} = 3\,105.116 - 11.456\alpha - 35.488\beta - 122.309\theta - 0.985P + 0.135\alpha\beta + 0.781\alpha\theta - 6.934 \times 10^{-3}\alpha P + 0.880\beta\theta + 0.171\theta^2 + 1.271\theta^2 + 5.090 \times 10^{-4}P^2 \qquad (3)$$

Based on the variable analysis and regression equations, the fuel-delivering angle θ is the most important factor of the four working parameters influencing the specific fuel consumption or thermal efficiency.

Table 2. Design Level of the Four Variables

Variable	Changing Interval	Design Level of Variables ($m_0=2$, $r=1.483$)				
x	Δj	−r	−1	0	+1	r
x_1	6.743	33	36.257	43	49.743	53
x_2	6.743	33	36.257	43	49.743	53
x_3	2.697	14	15.303	18	20.697	22
x_4	132.2	1 030.1	1 094.0	1 226.3	1 358.5	1 422.5

Table 3. Matrix of Structure in the Quadratic Regression Orthogonal Design

Test No.	X_0	X_1	X_2	X_3	X_4	X_1X_2	X_1X_3	X_1X_4	X_2X_3	X_2X_4	X_3X_4	g_{e1}	g_{e2}
1	1	1	1	1	1	1	1	1	1	1	1	399.95	359.90
2	1	1	1	1	−1	1	1	−1	1	−1	−1	301.69	362.97
3	1	1	1	−1	1	1	−1	1	−1	1	−1	304.83	333.05
4	1	1	1	−1	−1	1	−1	−1	−1	−1	1	312.56	362.97
5	1	1	−1	1	1	−1	1	1	−1	−1	1	282.07	292.56
6	1	1	−1	1	−1	−1	1	−1	−1	1	−1	304.78	344.23
7	1	1	−1	−1	1	−1	−1	1	1	−1	−1	309.77	343.51
8	1	1	−1	−1	−1	−1	−1	−1	1	1	1	308.87	342.15
9	1	−1	1	1	1	−1	−1	−1	1	1	1	302.61	336.83
10	1	−1	1	1	−1	−1	−1	1	1	−1	−1	292.37	336.83
11	1	−1	1	−1	1	−1	1	−1	−1	1	−1	311.16	350.45
12	1	−1	1	−1	−1	−1	1	1	−1	−1	1	314.45	357.67
13	1	−1	−1	1	1	1	−1	−1	−1	−1	1	291.14	295.02
14	1	−1	−1	1	−1	1	−1	1	−1	1	−1	304.33	289.12
15	1	−1	−1	−1	1	1	1	−1	1	−1	−1	346.94	409.16
16	1	−1	−1	−1	−1	1	1	1	1	1	1	329.93	390.69
17	1	r	0	0	0	0	0	0	0	0	0	299.52	310.31
18	1	−r	0	0	0	0	0	0	0	0	0	301.28	309.21
19	1	0	r	0	0	0	0	0	0	0	0	294.84	336.83
20	1	0	−r	0	0	0	0	0	0	0	0	314.00	317.78
21	1	0	0	r	0	0	0	0	0	0	0	297.81	327.31
22	1	0	0	−r	0	0	0	0	0	0	0	299.09	333.65
23	1	0	0	0	r	0	0	0	0	0	0	295.27	316.56
24	1	0	0	0	−r	0	0	0	0	0	0	314.46	342.87
25	1	0	0	0	0	0	0	0	0	0	0	298.23	330.45
26	1	0	0	0	0	0	0	0	0	0	0	296.11	323.63

Optimum Working Parameters

The regression equations of the two working conditions are taken as objective functions, and the test range of each working parameters is taken as constraint condition. Therefore, the nonlinear programming mathematics models will be:.

1. Working Condition 1

a. Objective Function

$$g_{el} = 1\,264.029 - 8.365\alpha - 8.476\beta - 22.335\theta - 0.549P + 0.0898\alpha\beta + 0.2215\alpha\theta + 0.2295\beta\theta + 2.1207 \times 10^4 P^2$$

b. Constraint Conditions

$33 \leqslant \alpha \leqslant 53$

$33 \leqslant \beta \leqslant 53$

$14 \leqslant \theta \leqslant 22$

$1\,030.1 \leqslant P \leqslant 1\,442.5$

2. Working Condition 2

a. Objective Function

$$g_{e2} = 3\,105.116 - 11.456\alpha - 35.488\beta - 122.309\theta - 0.985P + 0.135\alpha\beta + 0.781\alpha\theta - 6.934 \times 10^{-3}\alpha P + 0.880\beta\theta + 0.171\beta^2 + 1.271\theta^2 + 5.090 \times 10^{-4}P^2$$

b. Constraint Conditions

$33 \leqslant \alpha \leqslant 53$

$33 \leqslant \beta \leqslant 53$

$14 \leqslant \theta \leqslant 22$

$1\,030.1 \leqslant P \leqslant 1\,442.5$

With the help of computer, the optimal combinations of the four working parameters under the two working conditions are determined by using the nonlinear programming optimum method — composite function in order to resolve the two nonlinear programmings.

The results are shown as follows:

a. Working Condition 1

$\alpha=53°$, $\beta=33°$, $\theta=22°$, $P=$ 13.361MPa, $g_{el}=281.31$ g/kW.h

b. Working Condition 2

$\alpha=53°$, $\beta=33°$, $\theta=22°$, $P=$ 14.225MPa, $g_{e2}=302.15$ g/kW.h

Experimental Verification of the Optimal Combinations of the Working Parameters

The working parameters of the engine burning the blend of 30% cottonseed oil and 70% No.0 diesel oil were adjusted in accordance with the optimal combinations of the parameters obtained from above tests. The engine was then ran for about 1 h to attain a stable rated speed and torque. The specific fuel consumption under the two working conditions were measured as follows:

a. Working Condition 1: g_{el} = 286.65 g/kW.h

b. Working Condition 2: g_{e2} = 295.82 g/kW.h

The error rates of specific fuel consumption between optimum values and the test values in the two conditions were 1.9% and 2.1%, respectively.

Conclusion

Cottonseed oil is promising as an alternative fuel source for diesel engine because of its high gross heat content. It can be directly used as a diesel fuel and does not need any change in the structure of the engine. However, in order to get the highest power and thermal efficiency, the relevant working parameters of the engine should be readjusted. In the present study, the optimal combinations of the working parameters under the two working conditions of the engine were determined on the basis of a series of tests.

Based on the results of single variable test of fuel-delivering angle and quadratic regressive orthogonal tests of four working parameters, the main factor influencing the specific fuel consumption or thermal efficiency is fuel-delivering angle, and its optimum values under the two working conditions are all about 22 degrees, 3-5 degrees earlier than that of the engine burning pure diesel oil because cottonseed oil has higher viscosity and lower 16-alkame value and worst ignition characteristics. Therefore, it is necessary to increase the fuel-delivering angle for improving the combustion performance of the engine.

High viscosity of cottonseed oil is one of the key problems obstructing its wide application. The high viscosity leads to poor atomization and inefficient combustion of the fuel. Also, residues of partly combusted fuel remained in the engine to form deposits or to contaminate the lubricating oil. Now there are three approaches to solving this problem. They are: (a) reducing viscosity by heating it, because its viscosity-temperature characteristic curve is very steep, that is, its viscosity reduces rapidly as the heating temperature rises. Its viscosity is more than 10 times that of the pure diesel fuel when the temperature is about 20°C, but at a high temperature of 600-700°C, its viscosity is almost the same as that of the diesel fuel; (b) burning blend of cottonseed oil with diesel oil. It is very convenient to mix cottonseed oil with diesel oil at any proportion; (c) Esterifying cottonseed oil by putting in some alcoholates. Of the three approaches, using a blend of cottonseed oil with diesel boil is the most feasible in the PRC country-

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Natural Grain Drying Under Arid-region Conditions in Saudi Arabia

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Abstract

The arid region conditions in Saudi Arabia can be well used in the field of grain drying using the unheated-air technique. In this study, tests were made for wheat and barley grains in four identical bin models, supplied with a fan to deliver the designed unheated air. Air-flow rates chosen for the drying tests were: 350, 790, 1 200 and 1 400 ft^3/min (cfm). The initial grain moisture contents (MC) were 22.0 and 23.1% for wheat and barley, respectively.

Results have shown that the airflow rate and weather factors, especially air temperature and relative humidity, are the controlling factors to reach to the moisture ranges through which grain is to be dried at a certain time. One of the interesting results was that both wheat and barley grains reached to about 8% MC after 96, 48, 32 and 32 h of fan operation for the 1st, 2nd, 3rd and 4th airflow rates, respectively. This result may be useful in identifying grains characteristics. It is recommended that fast drying process be used because it is a reliable alternative in grain drying.

Introduction

Grains are living organisms and, like any other organism, they breath and produce energy. It is the function of storage to provide an environment in which changes in the seeds will be held to an acceptable level. Since the seeds are living, some changes will occur under any circumstances. Initially, each seed has a potential or capacity for germination. This potential cannot increase during storage but must continually decrease even though, under certain condition, it may be masked by temporary dormancy. Sooner or later the seed will be unsuitable for planting (Hukill, 1963). Temperature and moisture content of grain tend to control the rate of respiration and of deterioration. Grain storage operators use different techniques to maintain quality of grains in storage. Basically, grains have to be stored at moisture content level under which mold growth and insect activity are minimized. The influence of drying conditions on wheat-seeds germination was studied by LI et al (1988). In addition, the grain storage operator aims to prevent moisture migration which takes place whenever there is a variation in grain temperature.

Grain drying in humid and semi-humid region needs is time and energy consuming. As an example, Nellist and Bartlet (1988) simulated drying of a 3 m deep bed of wheat with 20% initial moisture content, using weather data for Lincolnshire, England and they concluded that continuous fan operation without the use of heat is not adequate to dry grain to 14% moisture content. On the contrary, to humid and semi-humid regions' conditions, the arid-region conditions, as represented in the Kingdom of Saudi Arabia, are distinguished by high air temperature and low relative humidity. These conditions are optimum for grain drying using unheated-air technique. In addition to the uncontrollable weather factors, the moisture ranges through which grain is to be dried and the rate at which the drying air is supplied are important factors influencing the effectiveness of unheated air drying (Foster, 1953).

From the view point of grain-storage engineering, grain can be aerated and/or dried with heated or unheated air. The latter technique occurs when a fan is used to force outside air through a grain bulk primarily to reduce the grain moisture content. Operating costs and weather conditions should be considered when selecting the suitable technique. These operating costs consist of power, maintenance, repairs and labour. The major operating cost is for electric power, which varies with the kind and depth of grain, air-flow rate, operation schedule, and hours of fan operation (USDA, 1961). The air-flow rate use greatly affects both the equipment required and the operating cost. Foster (1953) found that increasing the rate of air-flow from 2 to 4 cfm per bu through the same depth of grain will increase the power required about six fold, while the drying rate can only be doubled. Under circumstances where grain has not dried before it is put in storage, the storage itself is dependent upon reduction in the grain moisture, then the storage has another function, and it is necessary to design and operate it as a dryer (Hukill, 1963). However, for stored grain, fans are usually operated to pull the air down through the grain. To study the effect of different air-flow rates, tests may include measurements of temperature, grain moisture and atmospheric conditions.

In a study conducted by Morey (1987), simulated results for ambient air drying of maize showed continuous fan operation policies were preferable to strategies that involved controlling the fan based on relative humidity as far as minimizing grain deterioration and moisture differences in the bin are concerned. Energy savings with humidistat operation come at the cost of increased grain deterioration. Simulated results showed substantial differences in drying performance from year-to-year due to variation in weather conditions. Wheat drying showed advantages for humidist control and supplemental heat policies resulted in energy savings without increases in grain deterioration and moisture differences in the bin. The possibility of drying grain using energy-saving technology using aeration means fitted inside the grain bin was studied by numerous investigators. Raetskis and Palabinskis (1988) found that the dynamics of changes in moisture content and temperature of grain during ventilation in the bin had great effects on drying process.

Strictly speaking, the statement of the problem can be as follows: (a) Early harvesting followed by direct storage under relatively high moisture content of grain (i.e., more than 12%) can lead to damage by insects; (b) On the other hand, shattering and damaged grain occur as a result of late harvesting (i.e., when grain moisture content is less than 8%). This, in turn, leads to lose a considerable percentage of the yield; and (c) Accordingly, it seems that the solution is to start harvesting under relatively high moisture content. Then, the grain yield has to be dried in bins to the desired moisture content level. This can be achieved in a system where a fan continuously forces unheated air through the grain mass until the grain is dried to a safe moisture content level.

The objective of this work was to study the different factors affecting the unheated-air technique for wheat and barely drying.

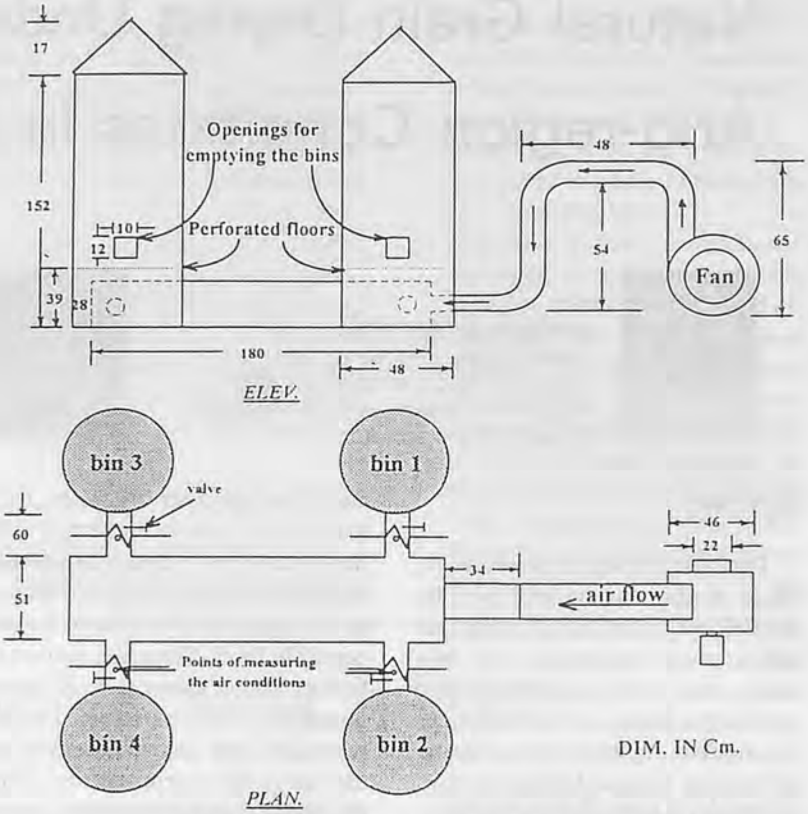

Fig. 1 Layout of experimental bin dryers.

Procedure

The experiment was carried out at the Food Engineering Laboratory, Dept. of Agricultural Engineering, Fauclty of Agriculture and Veterinary Medicise, King Saud University in Buriadah, Saudi Arabia. In order to execute the study, a model of four identical bins were fabricated from galvanized steel, supplied with a fan operating continuously to deliver unheated air to a distributor connected with the four bins. A flow-rate meter and a valve were connected to each of the four bin models in order to measure and control the air-flow rate supplied to the bin. Four air-flow rates chosen for the drying tests ranged from a high of 1 400 cfm down to a minimum of 350 cfm per bin model. The other two air-flow rates were 1 200 cfm and 790 cfm. Illustrated in **Fig. 1** is a schematic diagram of the constructed models. Temperature and relative humidity of the input air were measured using Veloci Calc plus*. Meanwhile, the relative humidity of the output air was measured by the same equipment. Tests were run for 143 kg and 116 kg per bin model of wheat and barley, respectively. Wheat and barley samples were taken in May 1994 from the field directly after harvesting. The initial moisture contents were 22.0% and 23.1% for wheat and barley, respectively.

Results of the drying tests were determined from samples drawn from each bin-model with standard sampling probes where moisture content was measured according to ASAE S352.1 (1986) on a wet-mass basis by oven-drying samples at 130°C for 19 h and 20 h for wheat and barley, respectively.

Results and Analysis

Impact of Ventilation

The effectiveness and impact of ventilation during the drying process were assessed by measuring temperature and relative humidity. **Fig. 3** represents the relative humidity inside and outside the bin models. The humidity patterns showed differences between outside and inside the bin models. Generally, such differences were most pronounced between outside and inside temperatures in bin No. 1 (i.e., under conditions of air-flow rate 350 cfm). This may be obvious due to the relatively high moisture content of grain dried in bin No. 1.

Figure 2 shows the variation in air temperature outside and at the top of the bin models. It can be seen that both the air-flow rate and the outdoor temperature have an effect on the resulting air-temperature which, in turn, may imply that it would affect the drying process.

Length of Drying Period Required

The rates of moisture reduction of wheat and barley grains ventilated at different air-flow rates are shown in **Fig. 4**. The mean moisture contents were generally reduced with prolongation of the ventilation period,; the higher the air-flow rate, the greater and faster was the decrease in moisture contents. The main features of moisture changes in ventilated bin-models were the time required to reduce the moisture content of both wheat and barely to 8% was 96, 48, 32 and 32 h of fan operation of the air-flow rates 350, 790, 1 200 and 1 400 cfm, respectively. The average grain moisture-

*The Model No. of this apparatus is 8360 and it is used for measuring temperature, humidity and air velocity, made by TSI Incorporated.

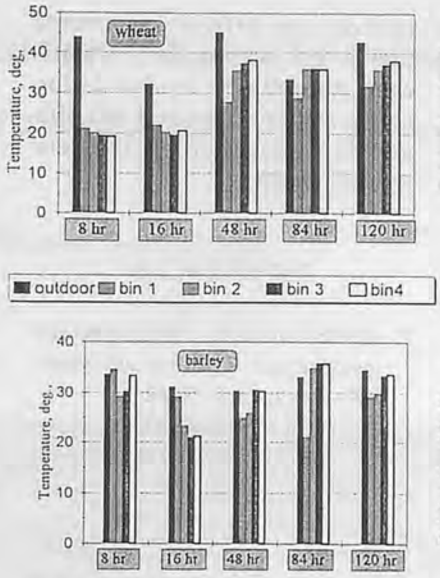

Fig. 2 Temperature variations atop bin models.

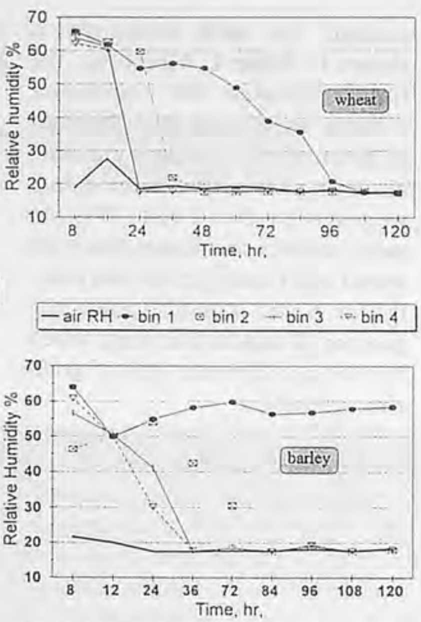

Fig. 3 Effect of air-flow rates on relative humidity inside bins.

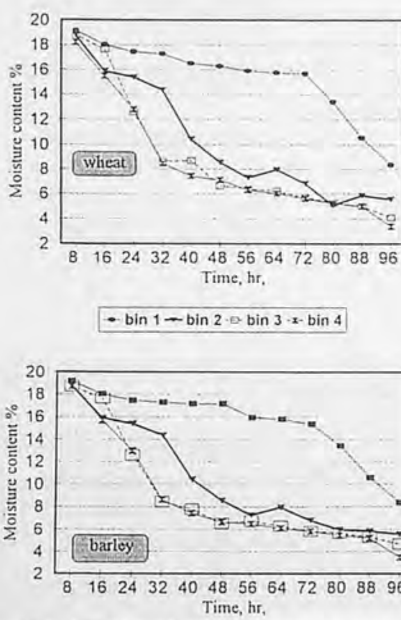

Fig. 4 Effect of air-flow rates on grain moisture content.

Table 1. Minimum, Maximum and Mean Moisture Contents of Grains During the Drying Process

(Unit: percent)

cfm	Grain	Min. value	Max. value	Mean
350	Wheat	7.55	20.05	15.59
	Barley	7.55	19.34	15.51
790	Wheat	4.81	18.77	10.27
	Barley	4.80	18.79	10.26
1200	Wheat	4.18	18.80	9.43
	Barley	4.17	18.81	4.92
1400	Wheat	3.03	19.05	9.03
	Barley	3.0	19.06	8.97

content for each treatment is shown in **Table 1**. Moreover, the results showed no significant differences between the behaviour of both wheat and barley during air drying when the obtained data were subjected to T test. This can pay in mind a conclusion that both wheat and barely grains had nearly the same trend during the process of unheated drying, which may be useful in the field of grain characteristics.

Economic Considerations

From the view point of economy, the cost of operation depends mainly on electric energy used to pull the volume of air by the fan which is required to reduce the grain moisture. In order to reduce grain moisture content to 8%, the volume of air were 560, 632, 640 and 746.6 ft for the air-flow rates of 350, 790, 1 200 and 1 400 cfm, respectively.

In the case under consideration, the time of air-drying process is not long which, in turn, makes the difference in the cost of operation between the different treatments that is not economically significant. Accordingly, the fast drying under air-flow rate of 1 400 cfm and fan operation of 32 h are recommended.

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Can Iron Wheels Provide a Solution to Agricultural Mechanization Problems in Developing Countries?

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Abstract

Primary cultivation of soil in arid and semi-arid regions require high drawbar pull which makes it necessary to use powerful tractors. Such tractors are costly to own and operate. Considering the sizes of land owned by the small farmers in the developing countries and their financial means, it is clear that such powerful agricultural machinery cannot provide the solution to the vital problem of mechanization in those countries.

This paper presents a theoretical approach to predict the tractive efficiency of small tractors fitted with iron wheels with lugs. The results of the analysis indicate that the drawbar pull of small tractors can be feasibly increased to provide enough drawbar pull required to cultivate arid land.

Introduction

It has long been recognized that in order to increase the agricultural production in developing countries, especially in Africa, the agricultural activities need to be mechanized [1-4]. Mechanization of agricultural activities in such countries faces a dilemma: On one hand, the land is tropical arid and semi-arid requiring high drawbar pull and hence greater power for plowing and tilling operations. On the other, the cost of such agricultural machinery is prohibitive to the great majority of the small farmers.

One of the foremost reasons for encouraging mechanization especially in African countries, is economics. Employment of animal power, though more by tradition than economics, is not a valid solution in many areas on account of the tse-tse fly problem [2-3]. In arid regions of Africa, a minimum drawbar pull of 5 kN is required for primary cultivation [4] which cannot obviously be furnished by the draught animals, Inevitably, the farmers have to wait for the rainy season before embarking on cultivation; thereby losing valuable moisture which leads to low yield.

The tyre drawbar output that could be developed by a land-moving vehicle is governed by the universal equation:

$$D_T = C_T W_T$$

where
D_T = Drawbar output
C_T = Coefficient of traction
W_T = Weight on the tractive wheels

Obviously, there are two possibilities to increase D_T and hence the drawbar pull of a farm implement: (1) to increase the weight W_T, and (2) to increase the coefficient of traction C_T. Increasing the weight results in a heavier farm implement which would have higher initial and operating costs, both of which are the foremost constraints of the problem of mechanization.

In the last decades numerous attempts have been made to develop feasible mechanization tools for tropical arid and semi-arid regions. Unfortunately, there seems to be no widely acclaimed success [5]. It was, therefore, found of both academic and practical interest to investigate the technical feasibility of equipping a small four wheel tractor with iron-wheels (with lugs) in order to increase the coefficient of traction.

Theory

Basically, there are two methods for modelling lug-soil interaction: (1) Slip line field theory and (2) Rankine passive earth pressure theory. The Rankine theory was used in this analysis for modelling the lug-soil intereaction mainly because this theory has been acknowledged to give good correlation with experimental results, both in prediction of force acting on a lug and rigid tines (6-7).

A close analogy between the

modes of failure encountered in long retainining walls and track laying tractor running gear has been shown to exist (8-10). This analogy is not limited to actual physical similarity, It can be extended to more significant factors associated with the modes of soil failures and actual surface geometry involved (11).

In general, the soil load (L) required to cause failure on a plane loaded interface can be expressed in terms of the following variables:

$$L = f\,[Y,\phi,C,\delta,C_a,Z,q] \quad (1)$$

which can be rewritten in the form suggested in Ref [11]:

$$L = YZ^2y + C_cZN_c + C_aZN_a + qZN_q \quad (2)$$

Where four terms of the equation represent gravitational, cohesive, adhesive and surcharge components of the soil reaction per unit width of interface. The factors N_y, N_c, N_a and N_q are termed the Reece factors and are a function of ϕ, δ and the geometry of the loaded interface.

Hettiaratchi et al (11) produced charts from which the values of the N factors for various δ, α and ϕ values as well as the rupture distance AD could be determined with negligible error for all practical purposes (**Fig. 1**). It must be pointed out that the figure is presented in its original form and thus there exists slight discrepancy between the symbols used for some of the variables in the figure and in this text. This cart is valid only to predict soil-lug interaction for purely frictional, purely cohesive and a c-ϕ type soil.

Mathematical Modelling of a Single Lug

In accordance with **Fig. 1**, the force L would be acting at an angle δ to the interface. If the angle of interface to the horizontal is α, the horizontal component (L_H) of the force L is

$$L_H = L\cos[\alpha + \delta - \frac{\pi}{2}] + C_aZ_c\cos\alpha\cos[\pi - \alpha] \quad (3)$$

Simplifying,

$$L_H = L\sin[\alpha + \delta] - C_aZ_c\mathrm{Cos}^2\alpha \quad (4)$$

Where Z_c is the lug's vertical depth given by the following equation

$$Z_c = Z\cos[\frac{\pi}{2} - \alpha] = Z\sin\alpha \quad (5)$$

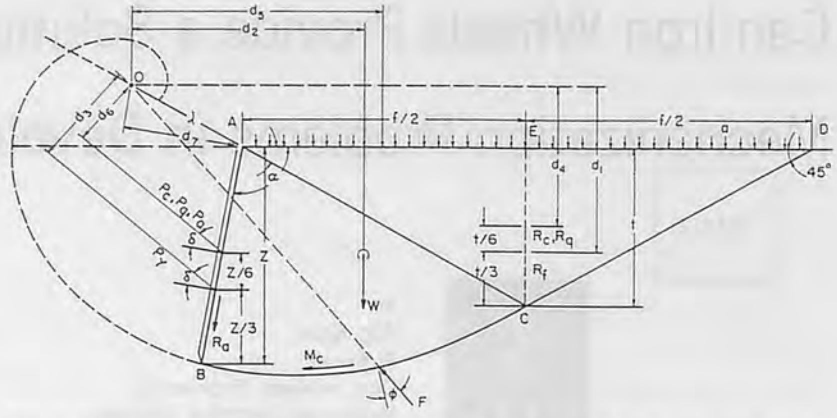

Fig. 1 Diagram showing logarithmic spiral failure boundary and the directions of various forces acting on the soil interface boundary (11).

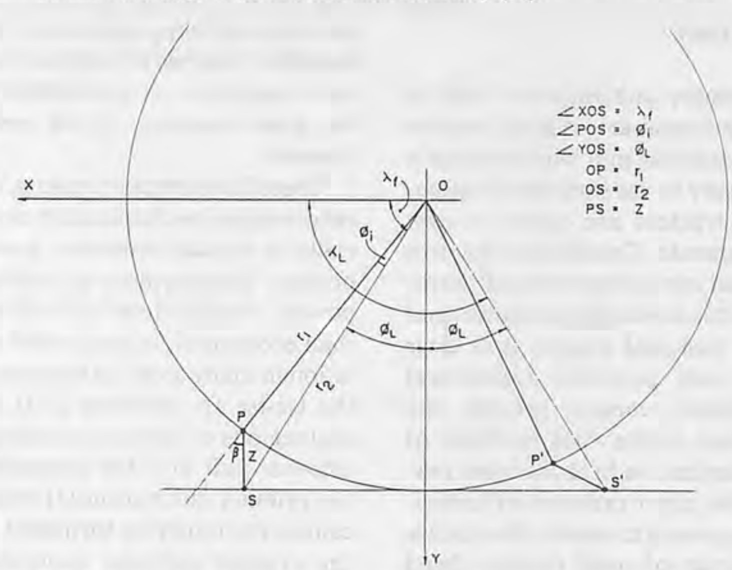

Fig. 2 A sketch of iron wheel showing the relationship of various angle.

in terms of the interface length Z.

Fig. 2 shows a schematic diagram of an iron wheel where all of the angular relationships required to derive the displacement equation are shown. For the sake of simplicity, the coordinate system is defined as shown. The angle λ is measured in the counter clockwise direction between the X axis and the line OS. In the figure, a lug is represented by a line segment; such as the line segment PS. Clearly, lug displacement can be described by the displacement of the points P and S.

From the figure, for a stationary wheel rotating about point O, the coordinates of points P and S are

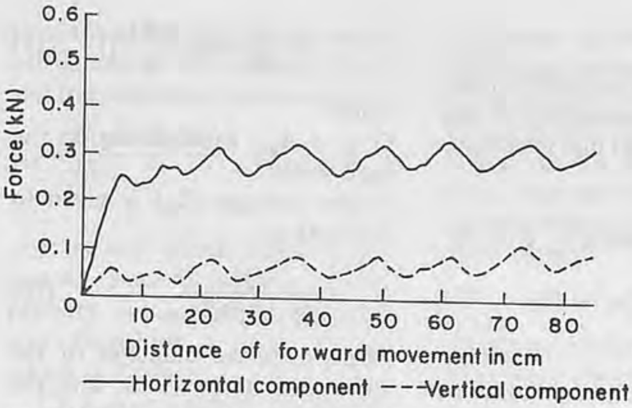

Fig. 3 Variation of load required to cause failure at boundary with displacement (12).

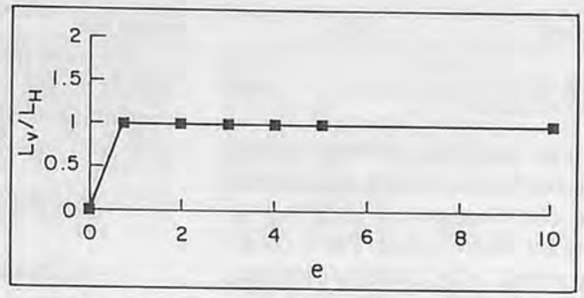

Fig. 4 Idealized variation of load required to cause failure at boundary with displacement (5).

$$P_x = r_1\cos[\lambda_f - \phi_i]$$
$$P_y = r_1\sin[\lambda_f - \phi_i] \quad (6)$$
$$S_x = r_2\cos\lambda_f$$
$$S_y = r_2\sin\lambda_f \quad (7)$$

where

r_1 = radius of the wheel

$$\phi_i = \tan^{-1}[\frac{\sin\beta}{(r_1/z) + \cos\beta}]$$

and

$$r_2 = \frac{Z\sin\beta}{\sin\phi_i}$$

where β is the lug's inclination and Z is the lug's length.

The lug comes into contact with the soil first at position S, describing the angle XOS which is designated as λ_f. Contact is lost when the lug is at position S'. It follows from the figure that:

$$\lambda_f = \frac{\pi}{2} - \phi_L$$

and

$$\lambda_L = \frac{\pi}{2} + \phi_L$$

the value of ϕ_L being,

$$\phi_L = \cos^{-1}[\frac{r_1}{r_2}]$$

Now, the coordinates of the points P and S can be expressed for any position of a rolling wheel. The equations include the wheel slip (s) which accompanies wheel motion.

$$P_x = r_1[1-s][\lambda - \lambda_f] + r_1\cos[\lambda - \phi_i]$$
$$p_y = r_1\sin[\lambda - \phi_i] \quad (10)$$
$$s_x = r_1[1-s][\lambda - \lambda_f] + r_2\cos\lambda$$
$$s_y = r_2\sin\lambda$$

These equations can be used to simulate the motion of the lug through the soil medium.

Modelling would not be complete without considering the high degree of compressibility exhibited by the soil. Based on the results of Gee-clough et al (12), Eq. (2) can be modified by employing the experimental results of Ref [12] to analyze the variation of forces at the soil interface with the interface's lateral displacement.

The cited results show that the resistance of the soil exhibits a cyclic behaviour. The forces increase almost linearly with lateral displacement of interface until failure occurs, and decreases abruptly just to rise again to a new peak, and so on (**Fig. 3**). This finding and the studies on soil mechanics (7) show that lateral displacement of long retaining walls required to cause failure at the soil-wall boundary is related to the depth of the wall in the soil, which could be expressed as:

$$K_W = \frac{L_W}{Z_W} \quad (11)$$

K_W = a constant depending on the soil type and condition

L_W = wall's lateral displacement, and

Z_W = wall's depth in soil.

Based on the same reasoning:

1 Lug's displacement (1) shown in **Fig. 1**, can be expressed by the lug's depth in soil, i.e.,
   1 = e.Z
   where e is a non-dimensional parameter and Z the lug's depth in soil.
2 The variable force required to cause failure at boundary with displacement could be defined as
   $L_Y = PL_H$
   where
   L_Y = The variable force experienced at the soil-lug interface.
   L_H = The force required to cause soil failure at the soil-lug interface
   P = Soil compressibility correction factor.
3 A linear relationship can be assumed between the force at the soil-lug interface and the lug's lateral displacement between failure. The force after failure can be assumed to be constant (**Fig. 4**). It is thus possible to model the soil's compressibility based on the idealized variation of load required to cause failure at boundary with displacement (5):

$$P = 1.428e = \frac{1}{Z_c}$$

$$\text{for } 0 \le e \le 0.7 \quad (12)$$

and

$$P = 1 \quad \text{for } e > 0.7 \qquad (13)$$

The drawbar pull that can be exerted by the tractor depends on the contribution of each lug in contact with the soil. For a rotating wheel, a lug's lateral displacement l_i is (5),

$$l_i = \frac{1}{2}[[r_1\cos(\lambda_f - \phi_i) + r_1\cos\lambda_f] - [2r_1(\lambda - \lambda_f)(1 - s) + r_2\cos\lambda + r_1\cos(\lambda_f - \phi_i)]]$$

and the lug's depth at any angle λ is

$$Z_c = r_2\sin\lambda - r_2\sin\lambda_f - Z_{in}$$

Prediction of Drawbar Pull

The maximum horizontal force per unit lug width required to cause soil-failure in the lug-soil interface is repeated below for convenience.

$$L_H = L\sin[\alpha + \delta] - C_aZ_c\cos^2\alpha$$

The angle α can be substituted by the following expression:

$$\alpha = \pi - \lambda - \beta \qquad (14)$$

and thus,

$$L_H = L\sin[\lambda + \beta - \delta] - C_aZ_c\cos^2[\lambda + \beta] \qquad (15)$$

When the resulting equation is multiplied by the soil compressibility factor (P) and the lug width b_i, the horizontal force experiences at lug-soil interface and thus, a lug's contribution to the drawbar pull is

$$T_i = b_i[PL\sin(\lambda + \beta - \delta) - C_aZ_i\cos^2(\lambda + \beta)] \qquad (16)$$

where T_i is the horizontal force which develops at the lug-soil interface.

The total tractive effort of the tractor is the summation of the contributions of all lugs in contact with soil, and is

$$T = \sum_{i=1}^{N_z} b_i[P_iL_i\sin(\lambda_i + \beta - \delta) - C_aZ_i\cos^2(\lambda_i + \beta)] \qquad (17)$$

where
Z_i = instantaneous depth of each lug given by the following equation;

$$Z_i = r_2\sin\lambda_i - r_2\sin\lambda_f - Z_{in}$$

L_i = maximum force required to cause failure at the soil interface boundary for the instantaneous depth of a lug, given by the following equation;

$$L_i = YZ_s^2N_{yi} + N_{ci}C_cZ_s + N_{qi}Z_sq + N_{ai}Z_sC_a \qquad (18)$$

where, for Eqs 17, 18,
N_{yi}, N_{ci}, N_{qi}, N_{ai}: Reece factors for each lug.
N_z: Total number of lugs in contact with soil.
P_i: Compressibility correction factor for each lug.
b_i: Width of the iron wheel.
With these equations, the resulting drawbar pull can be calculated.

Further Considerations

A) *Contribution of the unlugged area of the wheel in contact with soil to drawbar pull* — The unlugged portion of the wheel in contact with the soil also contributes to the drawbar pull. Employing the results in Ref [13] to predict the shearing resistance of the soil, the following equation could be obtained to estimate the thrust developed by the unlugged portion of the wheel (5):

$$T_{un} = CA_{un} + Q\tan\phi\{1 - \frac{k}{SL} + \frac{k}{SC}\exp[\frac{-SL}{k}]\} \qquad (19)$$

where
$Q = \sigma_i.A_{un}$: Load acting on the rigid wheel.

The sinkage (Z_{in}) is given in Ref (14) as,

$$Z_{in} = \frac{Q^2}{[5.7C]^2b_i^2d_i} \qquad (20)$$

where d_i is the diameter of the wheel and b_i its width, and the length of contact area is;

$$S = 2r_1\sin[\cos^{-1}[1 - \frac{Z_{in}}{r_1}]]$$

B) *The rolling resistance of the wheel* — The resistances are due to:

i- compaction of the soil, and
ii- shearing, distortion or distribution of the soil because of wheel motion [10].

The rolling resistance due to compaction of the soil can be estimated by means of the equation by Miklethwaite [14]:

$$R_c = \frac{Q^2}{(5.7C)^2b_id_i} \qquad (21)$$

where
R_c = Rolling resistance due to the compaction (kN)
C = Soil cohesion (kPa)
Q = Load acting on the iron wheel (kN)

The rolling resistance due to soil shearing and disturbances can be approximated by calculating first, the energy spent on shearing and disturbing the soil and then dividing it by the perimeter of the wheel (5); which in the final form is

$$E_{SL} = \frac{0.7Z_tb_iL_H}{2} + b_iL_H\langle l_t - Z_t\rangle \qquad (22)$$

The second term is applicable only if the difference is positive. In case the difference is negative, the lateral movement of the lug is smaller than the vertical depth and the energy expended is given by the triangular portion of **Fig. 4**.

Obviously, the total energy spent will depend on the number of lugs, and the resistance thus created is,

$$R_{LS} = \frac{N_i}{\pi d_i}\left[\frac{0.7 Z_t b_i L_H}{2} + b_i L_H < l_t - Z_t > \right] \quad (23)$$

It is well worth pointing out that R_{LS} is useful because, it helps primary cultivation by shearing and disturbing a layer of soil which is Z_t deep.

C) *Lug inclination* — The lug inclination is important in the sense that the initial lug-soil interaction should pierce the soil-not compress it. Based on this consideration, the initial lug-soil interaction angle is

$$\alpha_f = \pi - \lambda_f - \beta$$

where β is the lug inclination angle. Clearly the optimum value of α_f is $\pi/2$; thus

$$\beta_{opt} = \frac{\pi}{2} - \lambda_f$$

Since λ_f is independent of β, in this work, the value of α_f was taken between 1.4-1.75 radians.

D) *Lug spacing* — A lug which moves into position should not come in contact with already disturbed soil. Thus the spacing between the lugs is very important. Going back to **Fig. 1**, the maximum spacing is seen to be f, which is expressed as [11]

$$m = \frac{f}{Z_c}$$

where

m = a constant depending on the angle α_f and soil internal friction angle,

Z_c = lug's vertical depth

f = rupture distance

Finally, the number of lugs on the wheel is

$$N_i = \frac{\pi d_i}{m Z_c}$$

Although it is desirable to keep the number of lugs at minimum, care must be exercised that the power transfer is smooth and the rolling motion is jerk-free; which of course requires greater number of lugs. The results of this investigation showed that three lugs in contact with the soil satisfies both requirements.

Theoretical Evaluation of Tractor's Performance

Basak-17 is a locally manufactured tractor. It is representative in cost and size the type of tractor needed by the small farmers in Africa. The technical features of the tractor relevant to this investigation are given in **Table 1**.

A tractor's performance can be evaluated by using the tyre mobility number (MT) [15, 16] and coefficient of traction with slip.

$$M_T = \frac{C'bd}{W_T}\sqrt{\frac{\delta}{h}}\left[\frac{1}{1 + (b/2d)}\right] \quad (24)$$

where

C' = Soil cone index value (kN/mm^2)

b = Tyre width

d = Tyre diameter

W_T = Tyre load

δ = Tyre deflection

h = Tyre section height

The coefficient of traction, C_T, is the ratio of the tyre drawbar output, D_T, to the tyre load, W_T.

$$C_T = \frac{D_T}{W_T}$$

It has been shown in the cited references that C_M (the maximum coefficient of traction) is related to the tyre mobility number by the following equation

$$C_M = 0.796 - \frac{0.92}{M_T} \quad (25)$$

Likewise, the coefficient of rolling resistance is

$$C_R = 0.054 + \frac{0.323}{M_T} \quad (26)$$

Table 1. Basak Tractor's Technical Features

Model	: Basak 17
Power	: 17 hp at 3000 rpm
Max. torque	: 50 N.m at 2200 rpm
Weight on front axle	: 2290 N
Weight on rear axle	: 4900 N
Rear tyre dia.	: 814 mm
Cultivation speeds	: 0.88-1.74 m/s
Total weight with additional weights	: 8000 N

This equation is valid for tyres 0.8-0.95 m diameter tyres.

Thus a tractor's drawbar pull (D) can be determined from the equation:

$$D = \sum_{i=1}^{n_d} C_{Ti} W_{Ti} - \sum_{i=1}^{n_t} C_{Ri} W_{Ti} \quad (27)$$

where

n_d = Total number of driving wheels

n_t = Total number of tyres

C_{Ti} = Coefficient of traction for each driving wheel

C_{Ri} = Coefficient of rolling resistance for each tyre

W_{Ti} = Load on each tyre

The coefficient of traction (C_T) varies with tyre slip (s) as given by the equation below:

$$C_T = C_m[1 - e^{-Ks}] \quad (28)$$

where K is a rate constant which is related to the tyre mobility number by

$$KC_m = 4.838 + 0.061 M_T \quad (29)$$

Summary

In brief, the data outlined in the following tables were used to predict the performance of the Basak tractor when fitted with iron wheels [5].

These soil properties are those

Table 2. Soil Properties

Property	Value
Internal friction (deg)	10
Density (kn/m^3)	2660
Cohesion (kPa)	40
Adhesion (kPa)	85

Table 3. Iron-wheel Parameters [5]

Parameter	Value
Assumed wheel slip, S.	0.15
Soil cohesion (kN/M^2)	40
Soil internal friction angle (radians), ø	0.175
Tractor weight acting on the iron-wheel (kN), Q	2.40
Iron-wheel contact length (m), L	0.07
Soil deformation modulus (m), K	0.04
Wheel-soil contact area (m^2), A_{un}	0.021

Table 4. Rolling Resistances

Parameter	Value
Soil cohesion (C)	40 kPa
Load on rear wheel	2.4 kN
Horizontal force acting on Soil-lug interface	8.3 kN/m
Max. depth of lug in soil	0.045 m
Max. lateral displacement of lug	0.044 m
Resistance due to soil compaction	103.4 N
Resistance due to shearing and distribution	664.4 N

cited in Ref (17), based on the arid and semi-arid regions of East and Central Africa.

From the considerations discussed so far, the parameters related to the iron wheel are given in **Table 3**.

As mentioned earlier, the net drawbar pull of the tractor consists of the contributions of the lugged and unlugged portions of the wheel less the rolling resistances. The data used for calculating the rolling resistances and the resulting values are outlined in **Table 4**.

Finally, the theoretical performance of the Basak-17 tractor, when fitted with iron wheels is compared against the performance of the tractor when fitted with pneumatic tyres **(Table 5)**.

It is well worth reminding that these calculations were based on wheel slip-0.15, soil cone index value = 1500 kPa, and the soil properties given in **Table 2**.

The theoretical results show that the drawbar necessary to cultivate the arid land in Africa (> 5 000 N) could be achieved with iron-wheels. A useful further point for investigation could be the influence of the shape of lugs. Admittedly, there are other practical points to consider and considerable field testing may be required for realization. However, the results are highly encouraging to motivate prototype testing; the success of which could provide the much needed solution.

Table 5. Predicted Tractor Performance

Parameter	Pneumatic Tyre	Iron-wheel
Net drawbar pull (N)	2414	9560
Tractive efficiency (%)	72	82
Percent engine power utilization	15.8	62.7
Work-rate (ha/day)	0.51	2.02

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The Present State of Farm Machinery Industry

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Outlook of Agriculture

Trend of Agriculture

In 1994 agricultural total products was ¥7 586 billion, it occupied 1.6% of GNP. The imports agricultural products are on the increase. In 1995 the imports reached $39.4 billion (an increase of 9.0% of the preceding year). The exports agricultural products are $1.7 billion (an increase of 7.7% of the preceding year). In Japan, feed cereals, soybean, wheat and so on depend on the imports from foreign countries. Self-sufficiency ratio of agricultural products for food by calorey base in 1995 is 42%, cereals is 30%.

Population mainly engaged in farming has been decreasing yet, in 1995 it was 3 270 000 persons. It was 5.1% of total working population. Farm house has decreased, in 1995 are 3 440 000 farm houses. And, commercial household was 77%. Arable land was 5 040 000 ha in 1994. Arable land per one farm family was about 1.5 ha very small.

In Japan, food life has varied 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. Rice production at present almost planting and harvesting have been mechanized. In 1996 as to rice, working hours per 10 a decrease to 38.2 hours, they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to belargersized, higher-efficiency and more commonly used. In addition, farm machinery for field crops and live stock farming is being developed and improved, which had been lagged behind so far.

From 1993 Japanese government started the program developing the new high-tech machine to make farm working efficient and to reduce farm burden. By 1997 those developing have finished such as bigsize multi-purpose combine and vegetable grafting robot so on 18 types. And we decided eight types of unification for growing vegetables. Local governments have been developing the machine to vitalize special local products.

In 1995 Ministry of Agriculture, Forestry and Fisheries made a committee which studied method to reduce cost of farm product materials like farm machines. Those farm product materials are major parts of farming cost. In 1996 concrete movement started in the field of production and distribution.

Following are the numbers of popularization of farm machinery as of Feb. 1, 1995: riding tractor reached 2 309 000 units; walking tractor 1 714 000; rice transplanter 1 865 000; and head feed combine 1 202 000 (**Table 1**).

Shipments of major farm machinery in the domestic market in 1996 are as follows: riding tractor reached 94 000 units (those under 20PS were 32 000; those 20-30PS 390 000; 30-50PS 16 000; over 50PS were 7 200); walking tractor 174 000; rice transplanter 73 000; power reaper 18 000; combine 60 000 (standard types were 373); grain dryer 59 000; and huller 41 000. A safety cabin and a safety frame for tractor which are devoted to guarding operator increased sharply. This shipment was 79 000 units (**Table 2**). This shows a tendency that rice transplanters, tractors and combines with higher-horsepower, are decreasing in number.

Recently more and more used farm machines are distributed. The rate of used farm machinery

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
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	—	—	—	1,149	—
1995	1,718	2,313	1,869	1,921		1,022	1,203	1,121

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
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
1994	172,471	88,501	82,210	162,422	98,266	22,589	60,741	57,070
1995	163,323	90,623	81,729	162,352	96,499	23,293	64,572	60,564
1996	173,894	93,660	73,204	165,467	99,342	18,476	60,198	59,546

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

in the total sales amount is as follows: riding tractors forms 38%; rice transplanter 28%; and combine 33%.

Movement of Farm Machinery Industry

A production of farm machinery in Japan was over 600 billion yen 1994, 1995 and 1996. But in 1997 people say we are facing very severe condition. Because of over rice production.

In 1997 good weather made good rice harvest, and it continues three years. Government worries about surplus rice, and have to enforce set aside policy. Of course this situation weaken farmer's investment for farm machinery. As you know, almost of farm machinery in Japan are demands related to rice production.

We think major farm machineries are tractor, rice transplanter and combine. But, nowdays we have new type farm machinery, such as radio controlled helicopter, which spreading its field. At this time, radio controlled helicopter used for pest control. It has possibility of using for direct sowing methods in the paddy field and pest control in orchard garden, especially slope garden.

Farm machinery manufacturers have been doing mass-production as well as other industry. But great change will come soon. Manufacturers will have to adopt flexibility manufacturing system, as it were many-item little-production.

In Europe and U.S., precision farming is expected as new technology. Someone call it paradigm shift, it is fundamental change. How about Japan?, Japanese production is intensive agriculture, so we don't need precision farming. Is it true? Japanese agriculture is changing rapidly, we will need new technology in new future. Manufacturers must adopt this technology for Japanese future.

Trend of Farm Machinery Production

Farm machine production of 1996 amount of ¥637.2 billion (1.9% an decrease of over the preceding year).

Production of the major farm machinery is as follows: Riding tractor 152 956 units decreased by 0.6% under the preceding year. Seeing by h.p., those under 20PS amounts to 56 892 units, 20-30PS 59 903 units, over 30PS 36 161 units. Under 20PS have increased and over 20PS have decreased.

The production of walking tractor amounted to 214 702 units, which showed a increase of 4.3% over the preceding year. Under 5PS was 128 435 units, over 5PS 86 267 units.

The production of combine, which is next to the riding tractor is 63 371 units (an decrease of 5.1% over the preceding year). Main type is its harvesting wide is about 1 meter head feed type.

Following are the production of other types of farm machinery: rice transplanter amounted to 70 614 units (an decrease of 18.6% over the preceding year), binder (walking type harvesting machine for rice and wheat, barley, etc.) 21 541 units (an decrease of 21.8%), thresher 11 593 units (an decrease of 6.7%), grain dryer 64 969 units (an decrease of 4.0%), huller 60 021 units (an increase of 5.7%), bush cleaner 1 220 005 units (a decrease of 17.1%), power pest-controller 289 134 units (an decrease of 3.1%) so on **(Table 3)**.

Trend of Farm Machinery Market

In Japan distribution systems for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperatives Association. As of June 1994, the retail shops were recorded to about 8 800, the employees amounted to 43 000

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
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	—	606,279	156,039	198,278	212,539	30,921	85,837	66,726	141,556	6,569	123,268	5,670	6,260	8,261
1995	—	649,874	153,890	205,489	205,758	28,271	86,713	69,218	161,360	7,370	129,995	6,293	7,018	11,622
1996	—	637,209	152,956	201,357	214,702	31,400	70,614	57,581	154,260	6,752	126,594	6,121	8,280	12,843
(1997)		599,200	161,100	220,700	228,600	32,500	62,800	52,300	167,000	7,700	114,600	5,500	8,600	10,200

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
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	21,033	5,379	1,554,478	28,726	11,422	4,439	61,242	148,537	42,115	14,680	62,044	49,846	53,514	5,493
1995	27,562	7,484	1,471,192	27,731	12,422	4,751	66,767	162,329	56,792	21,178	67,700	56,215	56,590	6,755
1996	21,541	6,364	1,220,005	24,291	11,593	4,568	63,371	168,391	60,021	22,639	64,969	53,483	44,541	6,096
(1997)	14,400	4,100	910,000	20,200	8,700	3,400	55,500	151,600	54,700	20,700	55,400	46,300	38,300	5,100

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 1997 are forecast by Farm Machinery Industrial Research Corp.

Table 4. Farm Equipment Distributor and Sales Value

Unit: Million yen

Year	Number of retailers (1)	Employes	Annual sales value (2)	Inventory	Square meters of shop m²	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
1994.6	8,838	43,112	1,128,087	166,298	978,788	127.6

Source: Ministry of International Trade and Industry

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (1995 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
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
1993	2,905	353,340	267,609	388,337
1994	2,669	378,660	281,625	417,474
1995	2,457	374,952	283,193	413,664

Source: "Statistics on Agricultural Cooperatives—1995 business

persons, and the annual sales amounted to ¥1 128.0 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 ¥413.7 billion in 1995 (¥417.5 billion in 1994) **(Table 5)**. In 1994 numbers of Agricultural Cooperative was about 2 450, amount of dealing machines per Cooperatives was about ¥170 million.

About half of traders are small firm which employees are under 5. In a long time, it is important problem to improve management structure.

Export and Import of Farm Machinery

Export

In 1996 the exports of farm machinery amounted to ¥113.6 billion. Which showed an increase of 8.6% over the preceding year. The ratio of exports to the total production amounts to ¥637.2 billion ended 17.8%.

Seeing by the shipments, ¥51.9 billion for North America (an increase of 1.6%), ¥27.7 billion for Asia (an increase of 21%), ¥22.7 billion for Europe (an increase of 8.9%). For North America, ¥49.7 billion was U.S.A., tractor 50 690 units, ¥40.6 billion, which is a major part.

As for the types of farm machinery, tractor was chiefly exported: 85 173 units were exported in 1995 (the total production was 152 956 units). It amounts to ¥58.0 billion. Seeing by horse power, those under 30PS amounted to 64 506 units, those from 30 to 50PS 17 170 units, those over 50PS 3 497 units.

Major farm machinery, next to tractor, is bush cleaner. The toal exports were 946 041 units, ¥22.3 billion. The exports of other farm machinery are as follows: walking tractor 49 874 units; lawn mower 48 567 units; grass mower 37 083 units; chain saw 130 112 units, etc **(Table 6)**.

Import

In 1996 the imports of farm

Table 6. Export of Farm Equipment 1996

Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1990		132,757		
1991		129,943		
1992		143,891		
1993		124,505		
1994		120,079		
1995		104,597		
1996		113,586	100.0	U.S.A., Korea, France, Taiwan
Power tiller	49,874	3,270	2.9	France, Viet Nam, Germay
Wheel tractor	85,173	57,973	51.0	U.S.A.
Seeder, Planter	3,415	1,564	1.4	Taiwan
Power sprayer	39,675	1,418	1.2	Taiwan, Korea
Duster	15,034	488	0.4	Korea, Taiwan
Lawn mower	48,567	3,718	3.3	France, U.S.A.
Brush cutter	946,041	22,328	19.7	U.S.A., Korea, France
Mower	37,083	1,250	1.1	Korea, U.S.A., Malaysia
Combine	1,374	4,296	3.8	Taiwan
Chain saw	130,112	2,879	2.5	France, U.S.A., Italy
Other	—	14,402	12.7	

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

Table 7. Import of Farm Equipment 1996

Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exporters
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578		
1994		27,779		
1995		27,015		
1996		33,542	100.0	Germany, U.K., U.S.A.
Wheel tractor	4,224	15,760	47.0	U.K., Germany, France
Pest control machine	2,467,157	1,275	3.8	U.S.A., Taiwan, Israel
Lawn mower	64,641	2,802	8.4	U.S.A., Sweden, Germany
Mower	1,455	918	2.7	Netherlands, France Denmark
Hay making machine	1,613	966	2.9	France, Germany, Netherlands
Bayler	1,110	1,472	4.4	U.S.A., Denmark
Combine	76	1,111	3.3	Belgium, Germany
Chain saw	55,393	1,563	4.7	Germany, Sweden, U.S.A.
Other	—	7,675	22.9	

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

machinery amounted to ¥33.5 billion, which means a increase of 24.2% over the preceding year.

Followings are the major imported farm machinery: tractors 4 224 units (those more than 70PS were 3 317 units of all the tractors); chain saw 55 393 units, lawn mower 64 641 units, mower 7 585 units, fertilizer distributor 4 514 units. Tractors 1 591 units were imported from U.K. (**Table 7**).

Trend of Research and Experiment

The surroundings of Japanese agriculture are very hard, because of claims for opening the market for agricultural products by U.R. settlement, 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 structual and technical reforms in Japanese agriculture are requested urgently.

Researchers 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. In 1993, the law promoting agriculture mechanization was revised. "Urgent Development Program" which is promoting the machine has a weak demand, but has a strong needs, is going ahead. As a result, one of them like vegetables grafting machine is on market.

In 1996, in the field of farm machinery, there were movement as follows;

Tractor has developed auto-running systems, and that study has been continuing. Regarding tillage, high-speed rotary, saving-energy rotary has been developed. And paddy field leveling machine which has built in razor and personal computer has been developing.

In rice production, direct sowing methods are vigorous. A lot of kind method are studying. Studies have been developing, and which are management of irrigation water in the paddy field and machine weeding enviroment oriented.

In vegetable prolduction, technology of information each plant growth for realizing each plant growth management, grafting robot and many harvesting machines has been developing.

In citrus production, machines working in slope, fertilizer distributor, pest control machine and carrier studies have been developing. And non-destructive evaluation for fruits machines studies are developing.

In stock rising, development of management technology in steep slope grass field, improvement of silage adjusting technology, management of each livestock, slurry disposal technology for environmental problem have been developing. ■■

Outline of Activities of the Chugoku National Agricultural Experiment Station

by
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A Shot of History

The Chugoku National Agricultural Experiment Station (CNAES) was established as the Chugoku Wheat Breeding Station in Himeji, Hyogo prefecture in 1932. It was reorganized in 1952 with emphasis placed on research activities relating to agriculture in the Chugoku district. It transferred to Fukuyama, Hiroshima prefecture in 1962. The area for which the station was responsible was expended to the Kinki and Chugoku districts in 1973. It was reorganized further into three research project teams and five research departments, including integrated research for agriculture, agro-environmental management, crop breeding, upland farming and animal production in 1996 (**Fig. 1**).

Background of Research Activities

In the Kinki and Chugoku districts, various kinds of crops are intensively grown due to the favorable socio-economic conditions of the region. Agriculture is managed to make the best of the easy accessibility to large markets such as Osaka, Kobe, Kyoto, and cities along the Inland Sea Zone.

However, the hill-farming areas which account for the major part of these districts are confronted with many problems, including delay in land consolidation, very small scale of farm operation, exodus of young people to the cities, graying of the farm population and increase of abandoned farm lands.

Moreover, in the suburbs of the cities, the residents mingle with the farm population and the number of part-time farmers is increasing, leading to the promotion of an extremely intensive agriculture which causes the deterioration of soil fertility.

In order to alleviate these problems, studies were carried out to improve farm management in an effort to take advantage of the characteristics of the region and to meet the demands of the consumers for low-cost and steady supply of high-quality and safe agricultural and animal products.

Fig. 1 Gateway to the Chugoku National Agricultural Experiment Station.

Emphasis on Research Activities

The emphasis of research activities of the CNAES pertains to the following:

a. Farming systems using regional resources in hilly areas with relatively short access to big markets.

b. High-value production and increased productivity of main crops through plant breeding, cultivation methods, farm mechanization and post harvest technology.

c. Stabilized production of high-quality vegetables through intensive cultivation methods and soil management of upland areas.

d. Sustainable and high-quality production of beef cattle through management of genetic resources and grass land development.

e. Environmentally conscious production control of high-value products through management of pests, diseases and soil, and efficient use of local climatic resources.

The CNAES is headed by the Director General. Under his charge are the Department of Research Planning and Coordination, Department of General Administration, Department of Integrated Research for Agriculture (3 research project teams and 3 laboratories), Department of Agro-environmental Management (4 laboratories), Department of Crop Breeding (6 laboratories), Department of Upland Farming (3 laboratories), and Department of Animal Production (4 laboratories). The number of personnel is 207, including 98 researchers.

The Department of Integrated Research for Agriculture is engaged in research to establish a more profitable farm management system and rural revitalization programs which enable rural residents to live off the land permanently, based on analysis of agricultural trends and economic evaluation of new technologies. Above all, three research project teams have also been organized to do basic researches that apply to systems of growing vegetables, grassland development and regional marketing system.

The Department of Agro-environmental Management evaluates and utilizes available resources, i, e., soil water, climate, and the ecosystem. In addition, management practices are developed to control pests and diseases using natural enemies and antagonistic microorganisms in the ecosystem.

The Department of Crop Breeding carries out the following studies in response to demands: breeding rice and wheat of high quality, improvement of cropping type and cultivation method, development of new types of agricultural machinery, and development of new technology for the preservation of food quality. Researches have also been initiated to "robotize" farm work and to promote the genetic improvement of crops through the application of recombinant DNA techniques.

The focus of the Department of Upland Farming pertains to profitable vegetable growing. The main targets are as follows: local environmental stress reducing techniques under extremely high temperatures in summer or inadequate sunshine in winter conditions; labor-saving techniques; and continuous mono-cropping disease-reducing technique with the use of microorganisms or organic materials.

The Japanese black cattle (Wagyu, native to Japan) are known for their better beef quality throughout the world. At the Department of Animal Production, techniques for raising more healthy and tasty beef at minimal cost are developed through the use of local resources to carry on free trade. Semi-natural grassland is thus presently being studied for grazing and improvement of cropping systems is being attempted. Research on genetic improvement, increase in reproductive efficiency, nutritive management and meat quality evaluation of Wagyu beef are also being pursued.

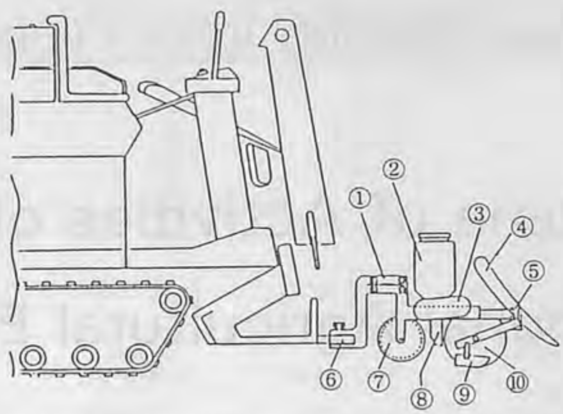

Fig. 2 No-tillage soybean planter equipped with combine harvester (① parallelogram link; ② seed hopper; ③ sprocket chain box; ④ divider; ⑤ axis; ⑥ axis; ⑦ press wheel; ⑧ infrared sensor; ⑨ opener; and ⑩ opener).

Current Research and Development Program

Five major areas of research and development are currently being pursued as follows:

1. Combination System of Soybean Planting With Wheat Harvesting Operation by Head-feeding Combine

In the southwestern part of Japan, on paddy-to-upland-converted fields, double cropping a year such as soybean and wheat is practiced with high productivity and low cost. In this system, soybean is planted from the middle of June to the beginning of July after wheat harvest. When the season is very rainy, delays in planting often affect soybean yield.

Therefore, a no-tillage planting technique simultaneously with wheat harvesting operation was developed (**Fig. 2**). The compact planter was attached to the front of a cutter bar of a combine. After a rotating disk opens the furrow, the soybean seed is planted. The total operation time for wheat harvesting and soybean planting is shortened by 0.8 to 1.0 hour per 10 ares compared to the custom method. The straw mulching after planting soybean proved effective in weed-control and bird infestation.

2. Multi-purpose Small Vehicle

A multi-purpose small vehicle was developed in order to expedite the operation of transplanting and harvesting while the operator seats on the vehicle (**Fig. 3**). This vehicle is 1.57 meters long, 34 centimeters wide, and 97 centimeters high. A small-sized sprayer was mounted to the vehicle for efficient spraying. The operator can control the speed of travel by the vehicle with the use of a handy lever.

3. Spinach Harvester

A spinach harvester which is loaded on a 4-wheel cart striding over rows of spinach plants was developed (**Fig. 4**). This is made up of cutting devices, pulling and conveying rubber belts, and gathering parts. After the V-shaped blade cuts the spinach root at a depth of 2 to 3 centimeters from the surface, a couple of soft rubber belts convey the plant to the upper part of the harvester.

Using the developed harvester for spinach, the hours of harvesting was reduced to one-tenth of the time in the manual harvesting method. However, there are some problems to establish the technololgy, especially the problem of quality of harvested spinach, i.e., the scratches, breaks and cut caused by mechanical harvesting.

Fig. 3 Multi-purpose small vehicle.

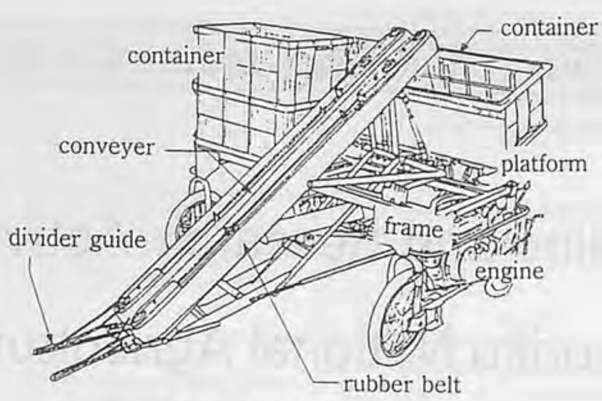

Fig. 4 Spinach harvester.

4. Mechanization Technololgy for Border Levee Weeding

Levee plastering and mowing works require much labor, hence expensive. A new method of covering levees by soil-mortar for weed control has been developed. Soil-mortar is made by mixing soil, cement and setting the material in the mass ratios of 1, 0.14, and 0.003, respectively, and by kneading the mixture with water. The preferable thickness of plastering is more than 3 centimeters. Using the disk type plastering machine attached to a tractor, the construction of levee covered with soil-mortar proved efficient (**Fig. 5**).

5. Utilization of Recycled Paper Mulching for Summer-season Vegetables

Now polyethylene mulching film is widely used for vegetable production. However, it requires much labor in removing the film after harvesting the crop and emits poisonous gas when being burned. Recycled paper mulching is a desirable method from environment conservation standpoint. Recycled paper is returned to the soil after use. Recycled paper is a little heavy and easy to break, but it can be stretched on farm by the ordinary mulching equipment (**Fig. 6**). Paper has an advantage of putting down ground temperature.

Fig. 5 Construction of levee covered with soil-mortar.

Fig. 6 Paper stretching operation using ordinary paper and mulching equipment.

As a result of the application test for Japanese radish culture in the summer season, it proved producing high-quality products through efficient weed control and 3°C drop of the maximum ground temperature. Therefore, paper mulching is useful for summer season vegetable production. ■■

Outline and Research Activities of Hokuriku National Agricultural Experiment Station

by
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Objectives and Background of the Experiment Station

Hokuriku National Agricultural Experiment Station (HNAES) is one of the national agricultural research institutes belonging to the Ministry of Agriculture, Forestry and Fisheries. HNAES is responsible for research and development of agriculture in Hokuriku district through improvement of crops and their farming system.

Hokuriku district is composed four prefectures i.e. Niigata, Toyama, Ishikawa and Fukui which are located in the central Honshu island along the coastline of the Japan Sea, with the extensive high mountain ranges behind as shown in **Fig. 1**. A climatic feature in the district is oceanic and under the influence of monsoons. Therefore, in summer, hot, a plentiful sunshine and humid weather predominates. On the other hand in autumn and winter, poor sunshine, a plentiful precipitation is a feature of the weather specially in winter the district is one of the heaviest snowfall area in Japan and the snow cover is long lasting.

Several coastal plains are developed at the outlet of the major river system. The rivers provide plentiful irrigation water for a crop. Large portion of the district has fertile and ill-drained heavy clays. As a result of such environments, rice cropping is predominant in agriculture. Arable land of the district is 350 thousand ha, 89% of which is occupied by paddy field.

However the district is one of the largest supply bases of high quality rice, the both imbalance between supply and demand of rice and international trade friction compel an adjustment of rice production as well as the establishment of more efficient rice based farming system for multi-utilization of lowland field.

Such agricultural background of the region concerned, the Hokuriku National Agricultural

Fig. 1 Location of HNAES.

Experiment Station, in close collaboration with the national and prefectural research organizations, pursues the following objectives:

1. Integrated technology for large scale rice production system and rice based cropping system for multi-utilization of lowland field;
2. Basic rice research with special emphasis on breeding of the high quality rice introducing the achievements of molecular biology; and
3. Technology to increase overall productivity in lowland farming taking environmental conservation into account.

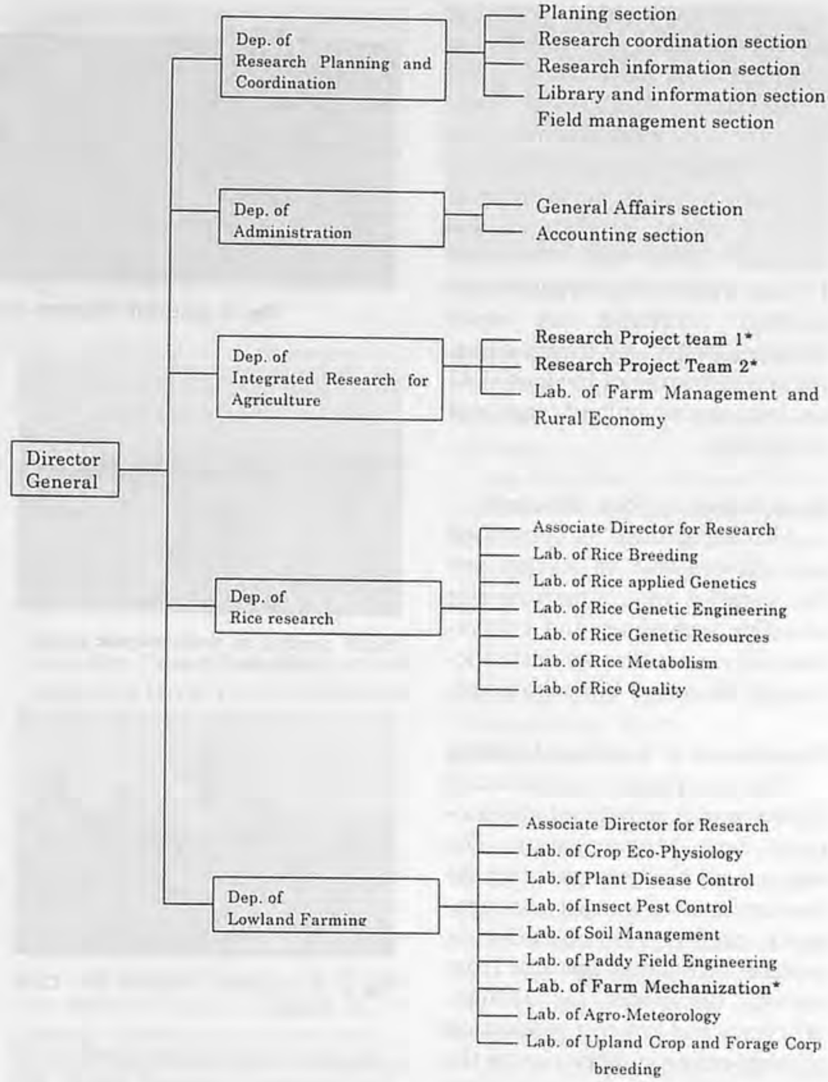
History of HNAES

The Hokuriku National Agricultural Experiment Station was founded as the Branch of Central Agricultural Experiment Station in 1944 at the present address. The HNAES was established as one of the seven national regional agricultural experiment stations in 1950. It started with a division of administration, a field management section and a research department involved seven laboratories. It has been reorganized several times.

In October 1996, the HNAES was finally reformed and Department of Integrated Research for Agriculture was newly established. The HNAES is comprised of Department of Research Planning and Coordination, Department of Administration and three Research Departments with 17 laboratories including two Research Project Teams.

Organization

The overall organization of the present HNAES is shown in **Fig. 2**. HNAES has a main campus at Joetsu-city, Niigata Pref. with about 13 ha of an experimental lowland field and about 9 ha of two experimental fields in the same prefecture. Total area of HNAES campus is about 33 ha. The number of total personnel are 136 and number of researchers including director general are 73.



* Section of Research involving agricultural mechanical engineer.

Fig. 2 Organization of Hokuriku National Agricultural Experiment Station.

Researches concerning agricultural mechanization and/or improvement of farm work are pursued on Laboratory of Farm Mechanization, Research Project Team 1 and Team 2, in which five agricultural engineers are involved.

Department of Integrated Research for Agriculture

The department is comprised of two research project teams and Laboratory of Farm Management and Rural Economy. The principle subject is to increase overall productivity of the lowland agriculture. The department is carrying out researches concerning the establishment of integrated technology and the studies of supporting farm management and the rural planning for progressive agriculture and activated rural community in the area.

Research Project Team 1 was organized to establish new rice direct seeding cultural technique suitable for large scale farming in order to reduce production cost specially labor cost. Research Project Team 2 was organized to establish profitable rice based cropping system by means of intensive utilization of lowland field i.e. introducing upland crops and vegetables.

Department of Rice Research

The department is comprised of six laboratories to develop new rice varieties and to innovate rice breeding techniques and cultivation techniques through introduction of advanced biotechnology.

Department of Lowland Farming

The department is comprised of 8 laboratories including Laboratory of Farm Mechanization. The department has been pursuing the development of proper management techniques considering environmental management from various disciplines for 1) high-efficiency and low cost production of high eating quality rice in the area; and 2) utilization system for highly profitable management of paddy field conquering natural adverse condition such as heavy snow fall and clayey soil with ill drainage.

Activities and Accomplishment Concerned Farm Mechanization and Improvement of Farm Work

New Rice Direct Seeding Culture System

Research Project Team 1 and Laboratory of Farm Mechanization has been developed a new rice direct seeding culture system of which the labor requirements are 45 man-hours/ha (cf. Average in Japanese conventional mechanical transplanting system: about 400 man-hours/ha) and the yield in brown rice is 5 t/ha almost same as average in the district. The system is comprised of field work system which is named tramlines farm work system, and new direct seeding cultural technique which is features of surface broadcasting of pre-germinated paddy seed onto puddled field and seedling establishment in condition of no standing water.

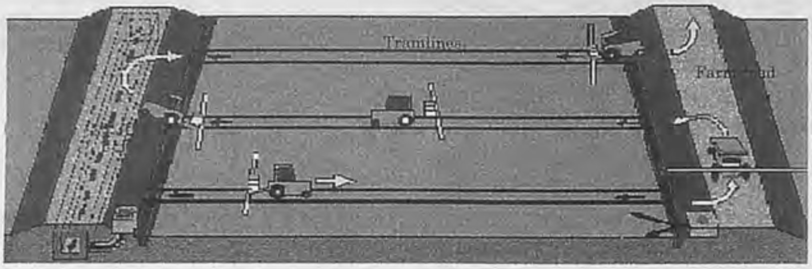


Fig. 3 Schematic diagram of tramlines field work system.

Fig. 4 Seeding by multi-purpose granule applicator.

Fig. 5 Crop caring by multi-purpose granule applicator.

Fig. 6 Autonomous Vehicle for Crop caring.

Fig. 7 Tractor mounted snow Press.

Tramlines Field Work System (Fig. 3)

In general, soil bearing capacity of lowland field under submerged condition is too weak to operate riding type vehicle for crop caring works such as chemical dressing and fertilizer application. Conventional methods of the works are carried out by means of knapsack type working machines from levee or in the rice field. Tramlines Field Work System has been developed to free from such as hard works in flooded rice field.

Tramlines Field Work System is in-field work system to utilize riding tractor. The tramlines, surface of which is reinforced by soil cement enough to operate a tractor, are laid at regular interval of 10 m. The tractor travels as drawing one stroke in the rice field for seeding and various crop caring.

Multi-purpose Granule Applicator (Fig. 4 and 5)

Multi-purpose granule applicator has been developed by Labora-

Fig. 8 Pilot dryer for soy bean and buckwheat.

Fig. 9 Construction of underground drainage.

Fig. 10 Cabbage transplanting.

tory of Farm Mechanization. It is mounted on high clearance tractor. It can be scattered with paddy seed, fertilizer and any granule chemicals at exactly 10 m wide suitable for tramlines field work system. The work rate of the machine is approximately 2 ha in a hour.

Autonomous Vehicle Using Guide-line Cable (Fig. 6)

Research on vehicle automation in a rice field has been conducting on Laboratory of Farm Mechanization. Induction coil installed the vehicle sensed induced current from guide line cable with high frequency current laying subsoil. The vehicle can travel prescribed pass autonomously No operator is required to operate the vehicle so that the worker on the vehicle can concentrate to adjust the implement or can be avoid to expose chemicals during chemicals top dressing.

Tractor Mounted Snow Press to Utilize Snow as Cold Temperature Resources (Fig. 7)

The prototype of snow press was developed by Laboratory of Farm Mechanization. It can make snow cube sized of 60 cm wide, 30 cm deep and 30 cm high. Pressed snow can be easier handling and more lasting than natural snow so that it is used to the cold resources for preserving agricultural product etc.

Humidity Controlled Air Forced Tempering Dryer for Soybean and Buckwheat (Fig. 8)

Pilot soy been dryer was developed by Laboratory of Farm Mechanization in order to improve quality as well as drying speed of high moisture soy been. The drying air is controlled not only temperature but also humidity. The dryer could dry 18.4% of soy been as high as 0.42%/h of average drying speed with minimum damaged kernels caused by drying.

Some Activities of Research Project Team2

Fig. 9 shows a scene construction of underground drainage using perforated plastic corrugated pipe for improvement of ill-drained lowland field in order to introduce summer and/or winter upland crop i.e. barley and cabbage.

Fig 10 shows a scene of transplanting of cabbage seedling using semi-automatic walking type vegetable transplanter in the lowland field.

International Collaboration Concerning Farm Mechanization

The HNAES has been accepted foreign trainee and researcher through the Japan International Cooperation Agency (JICA) and so on. Researchers in the HNAES have been dispatched to developing countries to carry out collaborative researches.

For recent examples concerning farm mechanization, two researchers were dispatched to the Philippine Rice Research Institute through JICA to develop paddy seeder suitable for Philippines Agriculture in cooperation with Filipino researchers. ■■

ERRATA

Vol. 28, No. 4, Autumn 1997, "Selection of Power Tiller for Bangladesh Farmers", page 18.
The photograph of the second author (M.A. Sattar) should be deleted as it as inserted by our mistake.
We offer our sincere apology for this mistake.

Education System at Okayama University and Research Activities of Laboratory of Agricultural Systems Engineering

by
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Education System

Location of Okayama University

Okayama City is the capital of Okayama Prefecture and has a population of approximately 600 000. It also has a convenient transportation netwwork linked with Tokyo, Sapporo, Sendai, Shikoku island, Kyushu island, Okinawa island, and Seoul (Korea) through direct air flights, Shinkansen Super Express Train, Seto-Ohashi Bridge, ferry boat, and etc.

Okayama University has 4 principal campuses and the Faculty of Agriculture, the Graduate School of Agriculture (Master cource), and the Graduate School of Natural Science and Technology (Ph.D cource) are in one of the campuses, which is called Tsushima Campus and is the main campus of the university. Tsushima Campus is located in the northern part of Okayama City and it takes about 15-20 minutes from Okayama Station by bus.

Fig. 1 Location of Okayama.

Faculty of Agriculture (Bachelor program)

The faculty of Agriculture is one of the leading institution of higher learning in the various fields of Agricultural Sciences in Japan. The faculty, originally founded as a college for higher agricultural education and research in 1946, became one of the several faculties when Okayama University was established in 1949, while Okayama University has 11 Faculties now. The Faculty of Agriculture has 8 departments as follows:

1. Department of Bioresources Chemistry;
2. Department of Biological Function and Genetic Resources Science;
3. Department of Eco-physiology for Crop Production;
4. Department of Animal Science

and Technology;
5. Department of Agricultural Products Technology;
6. Department of Agricultural Technology of Integrated Land Use;
7. Department of Agroforest Ecology; and
8. Department of Regional Resources Management

There are two loboratories regarding agricultural machinery in the Department of Agricultural Technology of Integrated Land Use; Laboratory of Agricultural Systems Engineering (Assoc. Professor Naoshi Kondo and Assist. Professor Mitsuji Monta) and Laboratory of Agricultural Machinery (Professor Kentaro Mohri and Assist. Professor Kazuhiko Namba).

Admission — The number of students admitted to the undergraduate program (Bachelor's degree program) of the Faculty is 140 every year. Applicants for admission to the undergraduate program must have graduated from 12 years of schooling, or equivalent education approved by the Ministry of Education, Science and Culture of Japan. Some students from other countries are admitted to the University. Applicants must have completed 12 years of schooling by the time of the entrance. Equivalent education (including International Baccalaureate Diploma) that is approved by the Ministry would be considered to meet the requirement. Application form for admission to the undergraduate program for the academic year that starts in April are to be sent to the admission office during the period in early February that will be announced by the University. The applicants are required to take an entrance examination for foreign students in February. For the detail information, applicants should contact the Admissions Office, Faculty of Agriculture.

Graduate School of Agriculture (Master program)

The Graduate school, established in 1969, offers advanced instruction and opportunity for research to qualified students and confers the degree of Master of Agriculture in 3 divisions; Bioresource Science, Agricultural Production and Technology, and Rural Science. As same with the Bachelor program, there are two research fields regarding agricultural machinery in the Department of Agricultural Technology of Integrated Land Use, Division of Rural Science.

Admission — Applicants for admission must have complete 4 years of undergraduate education (16 years of schooling) or the equivalent approved by the Ministry. Applications for admission are accepted in the period from August to September, and in February for the following academic year that starts in April. It is sometimes difficult for foreign students to be a regular graduate student immediately after arriving in Japan. It is, therefore, recommended that a foreign student enters the University as a research student, and take an entrance examination, then becomes a graduate student if qualified.

Graduate School of Agriculture (Ph. D program)

A doctor cource concerning the agricultural research field was first organized in 1985 in the Graduate School of Engineering. In 1986, one division of the doctor cource, Bioresource Science, was established in the Graduate School of Agriculture. The Graduate School doctor cource was reorganized in April, 1987, as the Graduate School of Natural Science and Technology, consisting of 5 divisions; Science and Technology for Materials, Science for Engineering and Agricultural Technology, Bioresource Science, Biopharmaceutical Science, and System Science. In 1992, a new division of Science and Technology for Intelligence was established.

Admission — Applications for admission are accepted in October, or in January. An entrance examination is held in each graduate division, however, students who graduated from the Master cource in Okayama University do not need to take the written examination.

Foreign students — In our two laboratories, 6 foreign students from China, Korea, Indonesia, and Egypt are studying researches on agricultural machinery in the graduate school, while 75 foreign students are in the whole Faculty of Agriculture (1996). They are from Bangradesh, Malaysia, Kenya, Iran, Philippines, Brazil, Vietnam, Senegal, Turkey, and Pakistan excluding the countries of students studying in our laboratories.

Research Activities of Laboratory of Agricultural Systems Engineering

Robotics for Bio-production

Many robots for bio-production have been developed in the world and it is predicted that they will be commercialized in the 21st century, since some of them were already commercialized by some companies in Japan and European countries. In our laboratory, robotics for bio-production and its machine vision systems are one of the most important research activities. Here, a tomato and cherry tomato harvesting robot, a cucumber harvesting robot, strawberry harvesting robots, a multi-operation robot to work in grapevine yard, and a chrysanthemum cutting sticking robot are introduced.

Tomato and cherry tomato harvesting robot — **Figure 2**

Fig. 2 Tomato harvesting robot.

Fig. 3 Cucumber harvesting robot.

Fig. 4 Multi-operation robot for grapevine.

shows a tomato and cherry tomato harvesting robot. This robot consists of 4 components: manipulator; end-effector; visual sensor; and traveling device. Here, those components are described.

A seven degrees of freedom manipulator was used to harvest larger size tomato and cherry tomato fruits as shown **Fig. 2** (Kondo et al., 1993; 1994c; 1995a). This manipulator could have high manipulatability when it had a harvesting posture. The manipulator consisted of two prismatic joints and five rotational joints. The lengths of upper arm and fore arm were 250 mm and 200 mm, while strokes of the prismatic joints are 200 mm in horizontal direction and 300 mm in vertical direction.

As harvesting end-effectors, two types have been developed; one is for larger size tomato fruit (Monta et al., 1994) and the other is for cherry tomato fruit. The former one had two fingers with a suction pad. The pad is able to suck a fruit pneumatically to separate if from the fruit cluster by the pad moving backward in the end-effector, because several fruits had adjacent positions one another and stems were also closed to the cluster sometimes. The end-effector for cherry tomato could suck a fruit into the end-effector pneumatically by a blower connected with the end-effector. When the fruit took an appropriate position in the end-effector, its peduncle was nipped around its joint by nipper closing. If the fruit was not at the position, the manipulator moved the end-effector's position back or forth until photo-interrupters told the appropriate position of fruit. The harvested fruit was transported to a container through tube between the end-effector and the container (Kondo et al., 1995e). A color CCD camera could be used to discriminate both fruits from their stems and leaves based on R, B, and G components, because matured tomato fruits had red color (Kondo et al., 1996c). The positions of the fruits were able to be detected basically by binocular stereo vision. A four wheel type traveling device which could travel in the ridge automatically was used for mounting the robot. This kind of traveling device was already commercialized as a vehicle for transporting in greenhouse. We are going to propell a project for a new tomato harvesting robot with a university in USA, an electrical company and an institute of agricultural machinery (Kondo et al., 1997b).

Cucumber harvesting robot — **Figure 3** shows a cucumber harvesting robot (Kondo et al., 1996a). As its manipulator, 6 DOF articurate manipulator was prepared to be able to work in the inclined trellis training system, which was developed for the robotic harvesting system. The training system made fruits hang down from its trellis to be able to detect fruits easily. Its visual sensor should be able to discriminate green fruit from green leaves and stems, since immatured fruit is usually harvested. In this robot, therefore, a monochrome TV camera with 850 nm wavelength interference optical filter was used to discriminate the fruit based on its spectral reflectance (Kondo et al., 1994a). In its end-effector, a peduncle detector, a cutter and fingers were installed, because it is difficult to detect peduncle position by the visual sensor and it is necessary to cut the peduncle. This project is colaborated with an agricultural machinery company.

Strawberry harvesting robots — Two types of strawberry harvesting robots have been developed. One is for hydroponic system and the other is for soil system. Since the plant training systems are different each other, two different types of robot are required. These robots also have similar components. The former robot is also cooperated with an agricultural machinery company.

Multi-operation robot for grapevine — **Figure 4** shows a robot to work in vineyard (Kondo, 1995f). In open field, harvesting period is so short that a harvesting robot may not be efficient if it is not able to do other operation. To make working period of the robot longer, several end-effectors were developed (Kondo et al., 1996d, Monta et al., 1995a). This robot has a polar coordinate manipulator with five degrees of freedom. The manipulator end could be moved on horizontal plane below the trellis at a constant speed under CP control. The length of the arm was 1.6 m, and the stroke was 1 m. In our laboratory, a harvesting end-effector, a berry thinning end-effector, a bagging end-effector, and a spray nozzle were attached to the manipulator end and experimented. This robot was a larger than the tomato harvesting robot and its mass was about 200 kg. A crawler type traveling device was prepared for mounting the robot.

Safety system for agricultural robot — When the agricultural robots actually work, safety system would be very important, since the robots are required to work operators cooperatively. Sensing systems using ultrasonic sensors and infrared sensors, which will be installed in the robots have been studied to avoid risky situation for human beings (Monta et al., 1997)

Chrysanthemum cutting sticking robot — **Figure 5** shows a robotic cutting sticking system (Monta et al., 1995b, Kondo et al., 1996b; 1997a). The system mainly consists of three sections; a cutting providing system, a leaf removing device and a planting device. First, a bundle of cutting is put into a water tank. The cuttings are spread out on the water by vibration of the tank. The cuttings are picked by a manipulator based on information of cutting position from a TV camera. Secondly, another TV camera recognizes the shape of cutting transferred from the water tank by the manipulator and detects its position and direction. The TV camera indicates the grasping position of the cutting for another manipulator. Thirdly, the manipulator moves the cutting to the leaf removing device and to the sticking device. Finally, the cuttings are stuck into a plug tray by the planting device. This robotic project is cooperated with JA and an electric company.

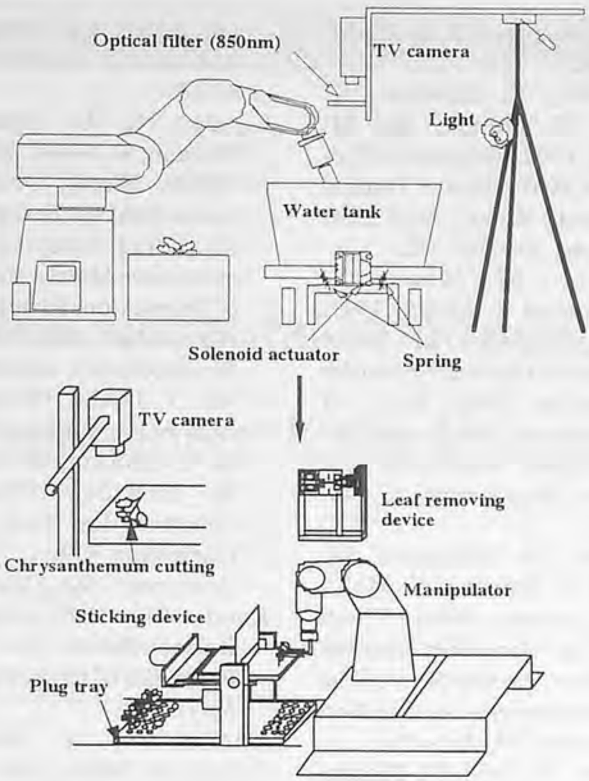

Fig. 5 Cutting sticking robot system.

Weed Detection in Lawn Field

Weeding is an essential operation for maintaining the beauty of lawn fields such as a golf cource and a garden. Specifying weed area is important for weeding, because wide chemical spray is not desirable. However, it is not easy to detect green color weed in green color lawn field. To find the weed area, a machine vision algorithm have been developed by using of textural analysis (Kondo et al., 1995d).

Plant Diagnosis System

In Japan, it is required to control plant growth especially in greenhouse and plant factory. To automate the plant growth control, it is necessary to monitor the state of the plant using machine vision. In our laboratory, a machine vision algorithm to recognize the plant shape based on the mophological features and a projected model of plant have been developed for the plant diagnosis (Kondo et al., 1994b).

Quality Evaluation for Agricultural Product

Quality evaluation of agricultural product is very important to enhance its market value. Machine vision system can be used for the evaluation and inspection system. We have developed the evaluation system combining to use machine vision and neural networks for orange fruits and chrysanthemum cut flowers (Kai et al., 1995, Kondo et al., 1995b; 1995c)

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Introduction of the Department of Environmental Information and Bioproduction Engineering, Kobe University

by
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Fig. 1 Location of Kobe City and Hyogo Prefecture.

General Information of Kobe, Japan

Kobe University is located in the Nada Ward of Kobe City. Kobe, together with Kyoto and Osaka, is one of the principal cities in the Kansai area, and is situated within three hours and twenty minutes bullet train ride from Tokyo, the capital of Japan and within one hour by train or jetfoil from Kansai International Airport. Kobe has prospered as an international port city and developed mainly through foreign trade. The population of Kobe is about 1 500 000 (including 40 000 foreign residents from 80 different countries), and the city faces the seto Inland sea to the south and has the Rokko mountains on her back to the north. This geographical condition provides various ways of enjoying the leisure in the mountains and on the sea. The living is highly comfortable.

Kobe is the location of the Hyogo Prefectural Government. Hyogo Prefecture is located roughly in the center of Japan, straddling the 135th meridian which is used to define Japanese Standard Time zone (**Fig. 1**). This large prefecture faces both the Japan Sea to the north and the Inland Sea and the Pacific Ocean to the south. Embracing the Hanshin and Harima Industrial Zones, the Port of Kobe and the Osaka International Airport, Hyogo Prefecture has long been one of Japan's centers of industrial production and international merchandise distribution.

The prefecture is also regarded as the food supply base for the entire Kinki District. Hyogo's gross agricultural turnover in 1990 grew up to 221.70 billion yen which constituted about 30% of that of the entire Kinki area. The total number of farms was 140 000 which was the third highest in Japan. Hyogo's varied manufacturing industry including food industry is located mainly in Hanshin and Harima regions along the coastal Plains. Food production in the prefecture reached 2.14 trillion yen in 1990 and it was the second largest in Japan. Kobe has long been renowned as a traditional center of Sake brewing. This product is generally held to be the very best in Japan.

Along the coastal plains of the Inland Sea, rice and vegetable farms have developed and livestock farming of broiler chickens and beef cattle are prosperous in Tajima District and rice production in Tanba District. Awaji Island District is famous for the production of onions, carnations and dairy cattle. Therefore, agriculture in Hyogo produces several characteristic products: Yamada-nishiki (a specialized rice variety for Sake brewing), Tanbaguro Black Soybean at Tanba, Onion in Awaji Island, famous "Kobe Beef" at Tajima. The highly variety of the products in this prefecture is due to various climate and its widely extended area.

Kobe University is one of the oldest and largest national universities in Japan with a high academic reputation. The origin of Kobe University dates from March 1902, when the Kobe College of Commerce was founded by the Government. The present Kobe University was established in 1949, integrating Kobe University of Economics, Hyogo Normal School, Hyogo Junior Normal School, Kobe College of Technology, and Himeji High School. The Faculty of Agriculture established in 1966 goes back to the Special Division of Hyogo Prefectural School of Agriculture established in 1919 which developed Hyogo Junior Normal School later. Division of Agriculture of Master Course Graduate School was established in 1972 and the Graduate School of Science and Technology (Doctor Course) in 1981. The organization of Kobe University consists of ten faculties, nine graduate schools, the Research Institute for Economic and Business, Administration, libraries and various other attached facilities and centers. There are two campuses in the University; Rokkodai main campus where the Faculty of Agriculture, Administration and other eight faculties are located and Kusunoki campus for the Faculty of Medicine and University Hospital. The number of staff is about 2600, Undergraduate students are about 12 500, Graduate students (Master's program) about 1 900, Doctoral program students about 1 000 and Foreign students about 500 in 1997.

Faculty of Agriculture

The organization of the Faculty consists of five departments: Department of Animal Science; Department of Plant Resource Science; Department of Biological and Environmental Science; Department of Biofunctional Chemistry; and Department of Environmental Information and Bioproduction Engineering.

Each department has two or three middle size laboratories and furthermore, a middle size laboratory consists of three to five small size laboratories. Therefore, there are 12 middle size laboratories consisting of 45 small size laboratories. The Faculty of Agriculture possesses University Experimental Farm at Kasai city 70 km west from Rokkodai Campus. The number of teaching and researech staff in the Faculty is 87 and the number of administrative staff is 27, Undergraduate students is 759, Master's course students is 71. The number of doctoral course students is 518, however, it includes the students in the divisions of science and technology in addition to the agricultural divisions (as of May, 1994).

Department of Environmental Information and Bioproduction Engineering

Education and research on Agricultural Engineering are carried out in the Department of Environmental Information and Bioproduction Engineering (EIBE). The annual entrant capacity of undergraduate students is 30 in the Department and that of graduate students in the master course is 12. Doctor course students belong to the Graduate School of Science and Technology.

The Department has two education courses: a course on Environmental Information and Regional Engineering (EIRE) and a course on System and Information Engineering of Bioproduction (SIEB). In the course on EIRE, education on agricultural civil engineering is carried out and the course on SIEB Provides education on agricultural machinery. The organization for research in the Department is also divided into the Laboratory of Environmental Information and Regional Engineering and the Laboratory of System and Information Engineering of Bioproduction. The former covers land development and maintenance as the foundation of bioproduction, analyses of environmental information concerning water and land resources, and environmental engineering of bioproduction. The latter covers mechanical, process, information and planning engineering for bioproduction, including post-harvest production and its systems.

The Laboratory of Environmental Information and Regional Engineering (EIRE) consists of four small laboratories; Water Environmental Engineering, Land Environmental Engineering, Regional Environment and Environmental Information. The Laboratory of System and Information Engineering of Bioproductions (SIEB) consists of four small laboratories: Mechanical Engineering for Bioproduction, Agricultural and Food Process Engineering, Information Engineering and Agricultural Machine Design and Mechanization.

The main research activities and research staff under each laboratory are as follows:

Environmental Information and Regional Engineering (EIRE)

Water Environmental Engineering

- Water Utilization System in River Basin
- Rainfall-Runoff Modelling
- Preservation of Water Environment
- Parameter Optimization of Rainfall-Runoff Models
- Flood and Drought Forecasting with Long-and Short-Term Runoff Model
- Effects of Land Reclamation on Hydrological Cycle
- Study on Effect of Land Development on Water Quality and Hydrology

Professor Hata, Takeshi D.Agr.
Associate Professor Tanakamaru, Haruya D.Eng. (Graduate School of Science and Technology)
Research Associate Tada, Akio D.Agr. (Graduate School of Science and Technology)

Land Environmental Engineering

- GIS database for earthquake disaster of irrigation ponds
- Cyclic behavior of soils under strain-path control
- Earthquake resistant design of filldams
- Analysis of Granular Flow

Professor Uchida, Kazunori D.Agr.
Research Associate Sakaguchi, Hide D.Agr.

Regional Environment

- Study on Seepage Failure of Soil
- Study on Filters in Geotechnical Engineering
- Study on Seepage Flow in an Anisotropic Porous Media

Associate Professor Tanaka, Tsutomu D.Agr.

Environmental Information

- Study on Cosmic Ray Composition by Air Shower

Associate Professor Sugihara, Takeshi D.Sci.

System and Information Engineering of Bioproduction (SIEB)

Mechanical Engineering for Bioproduction

- Development of Off-road Vehicle with Differential Gear System
- Dynamic Mechanism and Stress to Detach Fruits
- Vibration Characteristics of Plant and Tree
- Numerical Analysis of Agricultural Tire-Soil Contact Problem by 3-D Finite Element Method
- Development of 3-D Finite Element Tire Model
- Studies on Visual System for Robotic Harvesting

Professor Yamamoto, Hiroaki D.Agr.
Associate Professor Nakashima, Hiroshi D.Agr.
Research Associate Tokuda, Masaru D.Agr.

Agricultural and Food Process Engineering

- Drying Technology of Grains and Agricultural Products
- Application of Bioelectrical Impedance Spectroscopy in Postharvest and Food Engineering
- Development and Control of Flexible Actuator by Shape Memory Alloy
- Near Infrared Spectroscopy (NIRS) for Mastitis Diagnosis.
- NIRS as a Multipurpose Technology for Dairy Husbandry.
- NIRS for Biomonitoring.

Associate Professors Toyoda, Kiyohiko D.Agr. and Roumiana N. Tsenkova D.Eng.

Information Engineering

- Physical Properties of Agricultural Materials
- Control of Plant Growth by Color Image Processing
- Study of Improvement of Head-Feeding Type Combine with Optimum Control System
- Design of Spot Plow
- Yield Mapping in Rice Paddy Fields

Associate Professor Kawamura, Tsuneo D.Agr.
Research Associate Shoji, Koichi Ms.Agr.

Agricultural Machine Design and Mechanization

- Basic Studies on Farm Work by Radio-Control Helicopter
- Fine Chopper for Wood Materials
- Diffusion Process of Agricultural Technology

Professor Horio, Hisashi D.Agr.

Graduate School

The Graduate School of Science and Technology of Kobe University is an independent graduate school for advanced study and research, offering master's and doctoral degree programs, in natural science, engineering, agriculture, and related fields. The purpose of unifying the different disciplines into one graduate school is that education and research can be conducted from an interdisciplinary point of view and that cooperation among students and faculty members of different disciplines can be facilitated. The Graduate School of Science and Technology aims to provide the student with a wide professional scope and to make the student adaptable to any changes at the forefront of science and technology.

Maser's degree and the degree of Doctor of Philosophy (Ph.D.) can be conferred upon completion of the prescribed program of research and education, a qualifying examination, and the presentation of a dissertation, which must be approved by a committee. The degree of Doctor of Science (D.Sc.), Doctor of Engineering (D.Eng.), or Doctor of Agriculture (D.Agr.) may also be conferred depending on the nature of research and the type of training.

Master's Program

The master's degree program of the Graduate School of Science and Technology is divided into fifteen departments. Each department consists of two to five groups, and each group of two to seven areas of instruction and research. In the fifteen departments there are 43 groups and 183 areas of instruction and research.

A minimum of two years is required to complete the master's degree program. The student in the master's degree program must choose a major field of specialization from the 43 groups in the fifteen departments.

Applicants for the master's degree program must either have an undergraduate's degree or be judged by the faculty of the Graduate School of Science and Technology to be equal to undergraduate degree holders in academic standing.

Doctoral Program

The doctoral degree program is devided into seven divisions. Each division consists of three to four departments, and each department of seven to thirteen areas of instruction and research. The Graduate School has also established collaboration links with a number of prestigious institutions, and has created 6 "cooperative departments" linked to groups of research scholars from these institutions who are actively engaged in applied research and who act as visiting professors at the Graduate School. Altogether a total of 221 areas of instruction and research are distributed amongst the 30 departments of the seven divisions.

Three years are required to complete the doctoral degree program beyond the master's degree program. The student in the doctoral degree program must choose a major field of specialization from the 30 departments in the seven divisions.

Applicants for the doctoral degree program must either have a master's degree or be judged by the Faculty of the Graduate School of Science and Technology to be equal to master's degree holders in academic standing. Foreign students are admitted on the basis of previous academic records, recommendations, and thesis or published research papers.

International Exchange

Kobe University has been promoting the international cooperation in education and research service by accepting foreign students and researchers from all over the world. The academic exchange agreements have been concluded with over 30 foreign Universities including the Faculty of Agriculture of Washington State unversity, U.S.A.

Kobe University International Student Center (KISC) provide several services for international students: Japanese language and cultural instruction, guidance and counseling in their studies and everyday life affairs.

The students can be grouped into three categories; Those studying under the Ministry of Education (Monbusho) scholarships program, those studying with the assistance from their own governments and those studying on private funds. Application and selection of recipients of Japanese Government (Monbusho) scholarships are done through the recommendation of either the Japanese Embassy in the applicants country or Kobe University.

Applicants for the Graduate School are advised to contact the Department of EIBE through the Student Affairs Bureau of the University:

Student Affairs Bureau
Kobe University
1-1 Rokkodai-cho, Nada-ku,
Kobe 657, Japan
(Tel. +81-78-881-1212)

Acknowledgements: Hanshin and Awaji District had serious damages by the Great Hanshin-Awaji Earthquake of 1995, however, the City today has completed the reconstruction of the public facilities including the University buildings. Since the earthquake, we have received a great deal of assistance and help from many foreign countries. We thank you from the bottom of our hearts for all of your support and encouragement.

The some contents in this article was quoted from the below world wide web (www) and it is pleasure to acknowledge the cooperation of the authorities and the persons concerned. The more detail information can be given with the www on the Internet below:

Kobe University;
http://www2.kobe-u.ac.jp/
Faculty of Agriculture (in Japanese);
http://www.ans.kobe-u.ac.jp/
Kobe University International Student Center;
http://www.kobe-u.ac.jp/~kisc/def_Fe.htm
Kobe City;
http://www.kobe-cufs.ac.jp/kobe-city/
Hyogo Prefecture;
http://web.pref.hyogo.jp/index-e.htm

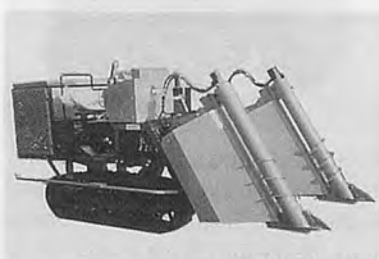
Main Products of Agricultural Machinery Manufacturers in Japan

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.

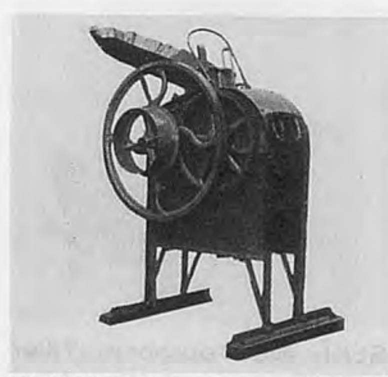
The products are developed and improved for both foreign and domestic markets. For further information please refer to the manufacturers contained in the directory.

ARIMITSU Knapsack Power Duster Model SG-7030. Light-weight, compact design, but ensuring to produce bigger air volume due to high performance turbo fan to be driven by the powerful 60CC gasoline engine. Chemical tank can be quickly mounted or detached by means of the lock or release lever. Size (L × W × H): 360 × 520 × 740 mm, Weight: 10.5kg, Max. output: 3.7ps/7 500 rpm, Chemical tank capacity: 28ℓ, Air volume: 14.9 m^3/min, Max. static pressure: 900 mm AQ.



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

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.



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 × 575W × 1,010L, Weight: Net 90kg Gross 130kg, Shipping meas.: 18 cft.

ISEKI TF325 Tractor. Mounted with powerful and economical 25PS water cooled diesel engine. The tractor offers wide range of travelling speeds from approximately 2 km/h to 22 km/h, which offers broad operating application and safe road travelling.

ISEKI SF300 Mower. The 28 hp 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: 1524/1830 mm, Cutting height: 30-120mm.

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. 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.

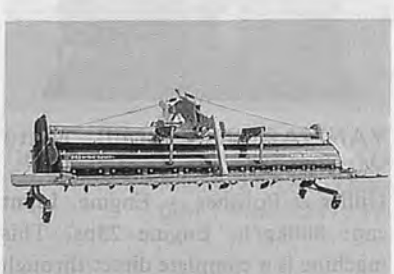
KUBOTA Diesel Engine RK125. Based on Kubota's advanced engine technology, the horizontal, water-cooled and 4-cycle diesel engine can provide full-bore power with less fuel consumption, higher output, and quick and smooth starting. For power tillers, tractors, pumps, generators, welders and other farm and industrial uses. Max. output: 12.5 HP /2400 rpm.

MAMETORA Vegetable Transplanter TP-4. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

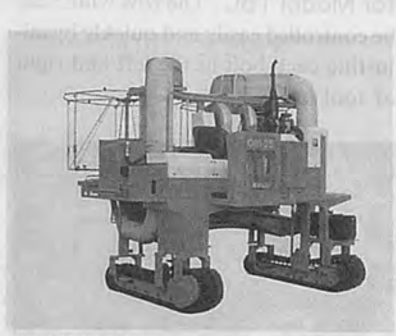
MAMETORA Power Cultivator SRV4F. Wide range use: cultivation to riding, Mounted with 7 PS engine.

MARUYAMA Portable Power Sprayers MSO55D. 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 Drive Harrow HR-2408B-3S for paddy field. Working width: 244 cm; Required tractor horsepower: 24 ~ 40 HP.

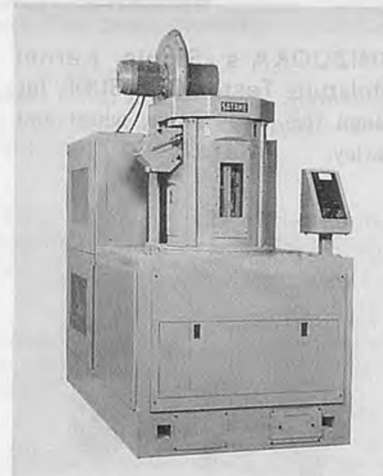


OCHIAI Riding Type Tea Picking Machine OM-25. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS.

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.

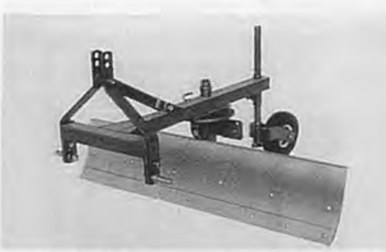


SATAKE New Rice Whiteness, Abrasive and Friction types, have high recovery, uniform & gentle milling, less installation space and high capacity. Model: VRM8A (Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/h brown rice.

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 0840. 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 Land Leveller Model TL-135. A tractor is operated most effectively when the field has been uniformly levelled.

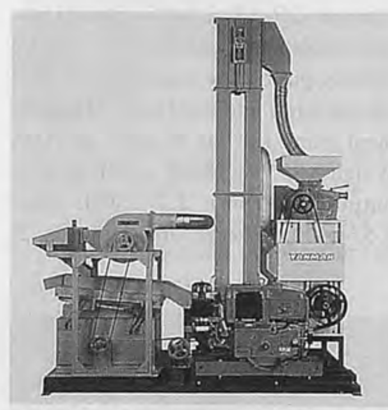
SUKIGARA Double Row Cultivator Model TBC. The row width can be controlled easily and quickly by adjusting each bolt at the left and right of tool bar.

TELAIRE CO_2 Concentration Measuring Equipment 2001 VTC. Telaire 2001VTC can watch necessity of ventilation, control air stream, measure air speed and control ventilation with fan in greenhouse. It can measure temperature and CO_2 by the infrared NDIR technique and diagnose condition of greenhouse automatically. Measurement range: 0 ~ 3000 ppm, Display indicator: 4 figures, Battery usable hours before next recharging: 2,11 h (2 types).

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.

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

YANMAR Diesel Tractor F-ex Series. 5 models: 21ps, 28ps, 32ps, 37ps, 42ps. Compact, quiet and vibration-reduced diesel engines are mounted at the heart of these F-ex series tractors. Engine: vertical, 4-cycle, water-cooled. Transmission: gear shifting. F8 × R8 or F9 × R9 Drive system. 4-wheel drive.



YANMAR New Mill Mate YMS-650U. Cleaner/destoner + 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. ■■

Arimitsu	Arimitsu Industrial Co., Ltd.—3-7, Fukae-kita 1-chome, Higashinari-ku, Osaka, 537-0001. Tel. 06-973-2010	OREC	Orec Co., Ltd.—548-22, Hiyoshi, Hirokawa-machi, Yame-gun, Fukuoka-pref., 834-0111. Tel. 0943-32-5002
Bunmei	Bunmei Noki Co., Ltd.—11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890-0065. Tel. 0992-54-5121	Robin	Fuji Robin Industries Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410-0022. Tel. 0559-63-1111
Chikuma	Chikumasuki Co., Ltd.—356 Koya, Yoshikawa, Matsumoto-city, Nagano-pref., 399-0031. Tel. 0263-58-2055	Sasaki	Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomori-pref., 034-0000. Tel. 0176-22-3111
Daishin	Daishin Industries, Ltd.—23-1, 3-chome Yoyasu-cho, Ogaki-city, 503-0858. Tel. 0584-75-5011	Satake	Satake Corp.—7-2, Soto-kanda 4-chome, Chiyoda-ku, Tokyo, 101-0021. Tel. 03-3253-3111
Iseki	Iseki & Co., Ltd.—3-14, Nishi-Nippori, 5-chome, Arakawa-ku, Tokyo, 116-0013. Tel. 03-5604-7600	Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437-0042. Tel. 0538-42-3111
Kioritz	Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo, 198-0025. Tel. 0428-32-6118	Star	Star Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066-0077. Tel. 0123-26-1122
Kubota	Kubota Corporation—2-47, Shikitsu-higashi 1-chome, Naniwa-ku, Osaka, 556-0012. Tel. 06-648-2111	Sukigara	Sukigara Agricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444-0943. Tel. 0564-31-2107
Mametora	Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363-0017. Tel. 048-771-1181	Telaire	Wistas Engineering Co.—Blk 13 Upper Thomson Road 01-71J, Singapore 570013. URL http: //www.telaire.se/press.html
Maruyama	Maruyama Mfg. Co., Inc.—4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo, 101-0047. Tel. 03-3252-2271	Tiger	Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 323-1104. Tel. 0282-62-3001
Minoru	Minoru Industrial Co., Ltd.—447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama-pref., 709-0816. Tel. 08695-5-1122	Yamamoto	Yamamoto Co., Ltd.—404, Oinomori, Tendo-city, Yamagata-pref., 994-0013. Tel. 0236-53-3411
Niplo	Matsuyama Plow Mfg. Co., Ltd.—5155, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref., 386-0401. Tel. 0268-42-7500	Yanmar	Yanmar Agricultural Equipment Co., Ltd.—1-32, Chaya-machi, Kita-ku, Osaka-city, 530-0013. Tel. 06-376-6336 ■■
Ochiai	Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439-0037. Tel. 0537-36-2161		

8th National Symposium on Individual and Small Community Sewage Systems

March 8-10, 1998
Hyatt Orlando, Orland, Florida, USA

The purpose of this eighth symposium is to continue the ASAE commitment to providing important information on individual and small community sewage treatment. Professionals will share research and discuss critical issues.

Held in conjunction with the 7th International Drainage Symposium.

Contact: ASAE if you would like a copy of the program.

Sponsored by: ASAE, The Society for engineering in agricultural, food, and biological systems.

ASAE Annual International Meeting

July 12-15, 1998
Orlando, Florida, USA

ASAE Announces Call for Presentations

The following numbering system is designed to help you find the topic areas of interest to you. The topic areas listed below are general groupings. Some sessions may be of interest to people in other technical areas, so please review all of the session titles. Please use the number for each session on your submission form to identify the session you are submitting your paper for.

The technical sessions at the meeting are divided into the following topic areas:

100s = Power and Machinery
200s = Soil and Water
300s = Information and Electrical Technologies
400s = Structures and Environment
500s = Emerging Areas
600s = Food and Process Engineering
700s = Other areas (business development, safety, sustainable agriculture, education, etc.)

For your paper to be considered, you must follow all the instructions in this brochure. If your paper is accepted, an official notification letter will be sent from ASAE headquarters on March 30, 1998.

Proposals should include: a) an objective, b) the methodology, and c) the expected results and their implications. Do not include graphs, charts, plots, equations, superscripts, subscripts, tables, illustrations or references in your proposal.

Session Types

The meeting will include both Lecture Sessions and Poster Sessions. Presentations will be chosen for lecture sessions if the organizers believe that the lecture format is most appropriate. Poster sessions will be used where the range of presentations lends itself to this format. Detailed instructions will be sent to all presenters with the notification letters in March 1998.

Poster Sessions — Poster presentations afford maximum opportunity for direct interaction between the presenter and the audience. Poster session presenters are expected to be available for a specified period of time to discuss their work.

Lecture Sessions — Presenters are provided with a 35 mm slide projector, overhead projector and pointer. Oral presentations are generally limited to 10 to 20 minutes, depending upon the number of presentations in the session and the time slot in which the session is scheduled.

Tutorials, Workshops & Rap Sessions — Tutorials, workshops and rap sessions are other formats used for programming. The format is determined by the session organizers and are usually invited presentations.

Deadline

January 9, 1998
Presentation proposal forms due to Session Organizers via E-mail, FAX or regular mail

March 30, 1998
Notification of acceptance and instructions mailed to presenters

July 12-15, 1998
ASAE Annual International Meeting

For information about how to submit a manuscript to an ASAE journal call ASAE at 616.429.0300, send a FAX to 616.429.3852, or send an e-mail to hq@asae.org, or write to us at ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA.

CIGR International Symposium — Dust Control in Animal Production Facilities

31 May - 2 June, 1999
Jutland, Denmark

This is the first announcement of the international symposium of the Second Technical Section of CIGR in Co-operation with EurAgEng, Scandinavian Association of Agricultural Scientists, NJF, and Danish Society for Agricultural Medicine, DJS.

The symposium will be organized by the Danish Institute of Agricultural Sciences, DIAS, and guided by an international scientific committee.

The purpose of the symposium is to exchange information on the development within dust measurement and abatement, animal welfare and health, human health risks and the epidemiological function of dust particles related to animal production facilities.

Scientific programme

The following topics will be discussed at the symposium:

- Sources of dust and characterization of dust

- Measurement of dust concentration and particle size
- Dose response and control standards
- The impact of dust on animals
- Health risks for humans
- Effect of dust emissions on the environment
- Modelling of dust concentration distribution indoors and in the surroundings
- Dust reduction techniques

General correspondence

Dust Symposium 1999
Research Centre Bygholm
P.O. Box 536. DK-8700 Horsens, Denmark. Phone: +45 75 7602211, Fax: +45 75 624880, E-mail: sp6@sh.dk

Club of Bologna — Conclusions and Recommendations of the 8th Meeting

48 Experts from 25 countries attended the 8th Club of Bologna Meeting-held under the auspices of CIGR-discussing the two following main subjects: (1) Contractors: new machines to increase efficiency of the various field operations; (2) Role of electronics and decision support systems for a new mechanization. A short preparatory session has been dedicated also to the introduction of a European MSc on Agricultural Engineering (EUTRAC). The meeting reached unanimously the following:

1 - Contractors: New Machines to Increase Efficiency of the Various Field Operations

This subject — already preliminarly discussed in 1992 — has been considered with reference to the various geographical areas, with contributions from the following key-note speakers: *A.M. El Hossary* (Egypt); *A. Lara Lopez* (Mexico); *H.D. Kutzbach* (Germany); and *R. Guidotti* (Italy). This last one expressed the point of view of the contracting associations.

The papers presented and the discussion had **confirmed**, first of all, the growing technical and economic role plaied by contractors for carrying out field operations. This with reference to both the industrialized and developing countries even if the present situation shows a high diversification as far as the number and the diffusion of contracting enterprises are concerned.

While very uncommon is in all countries the utilization of contractors to carry out all the field operations — from soil preparation to harvest — of specific crops, it has been underlined that the more common operations carried out by contractors concern cereals and forages harvesting, as well as other main herbaceons crops. In some country the activity for grapes and olives harvesting is under development too. The above operations are followed, in order of diffusion, by the following ones: soil cultivation, sowing, chemicals (pesticides, herbicides and fertilizers) distribution. All this influences the agricultural machinery market. Infact, almost in the industrialized countries, over 60% of the cereals and forage crops harvesting machines is due to contractors.

On the basis of the above positive considerations, the participants — after an ample and indepth discussion — **agree in confirming** that, to maximize the technical and economic advantages of contracting services, it is necessary to guarantee the fulfilment of specific technical and operational requirements as well the solution of management problems of each contracting enterprise.

As far as the first aspect is concerned, it has been underlined the need for a complete availability of machines expressly realized, appropriate in terms of: work capacity, running security, simplicity of maintenance, complete automation, easyness of manoeuvrability, low energy consumption, environment protection, better work quality and reduction of workers tiredness.

The second aspect concerns the structural and management problems of the contracting enterprises which need to make use of: highly specializes drivers and mechanicians; capability to optimize the choice of machines appropriate to the agronomic and economic requirements of farmers; capability to be organized under specific official regulations in order to offer to the farmers the maximum of confidence.

The participants, consequently, **recommend** unanimously that:

- from the *manufacturing* point of view, the machines — both self-propelled and tractor drawn — need to offer: a working capacity able to increase the timeliness of various operations and the workable areas within the useful times; the simplification of maintenance operations that have to be automatized, less frequent and possibly to be done also during the transfer periods from a farm to another; the wide introduction of automation of both internal components (e.g. hydraulic infinite variable transmissions) and external safety and operational control. To this end the use of electronic systems for active control of the work developed and its quality has to be encouraged. This includes also DGPS devices able to meet the requirements of precision farming. In addition it is to underline the need to have strong machines that, at the same time, have the possibility of a quick technical obsolescence in order to offer to farmers in any time what the technical progress can provide;
- from the *management* point of view, the contracting enterprises structured in a modern and rational manner, need to have: sizes adequate to guarantee the best services for farmers; modern and well maintained machines; skill technicians and

drivers. A further guarantee will come from the compulsory subscription of contractors to a public national register, while a further spreading of these services will be reached with a rigorous technical and economic control through transparent, official budgets.

2 - Role of Electronics and Decision Support Systems for a New Mechanization

This subject has been examined on the basis of four key-note reports presented by: *H. Auernhammer* (Germany); *J.K. Schueller* (USA), who expressed the point of view of research; *A.R. Rider* (USA) and *W. von Allwörden* (Germany), who presented the point of view of industry.

All the participants, above all, **recognized** the growing importance of electronics for a modern mechanization and underlined the link of this subject with the one previously examined concerning contracting. Infact, electronic devices and decision support systems are even more massive incorporated in tractors and equipments with high work capacity, big hourly utilization and, then, a prevailing use by contractors.

At present electronics is used in few basic areas concerning respectively: the reduction of workers tiredness; the increase of machinery performances; the process control on the optimization of the relationship between machine, soils, plants and animals.

While the first two aspects were the basis of electronics — when it was firstly introduced 25 years ago — applied to tractors and implements, the other two aspects represent the most modern tendency due to the fact that — permitting a dialog between machines and environment — aims to realize the technique of precision farming crucial for the realization of a rural activity sustainable from both economic and biological viewpoints.

The main tractors manufacturers, in fact, once solved the main problems of electronic applications within the tractors — such as for the transmissions — and able to communicate — through BUS systems — with the attached equipment, are at present oriented to realize decisional systems to support agricultural processes and the environment.

However, the participants — taking into account the growing farm sizes and the increasing use of contractors — **underline the need** to develop and spread out electronic solution connected with satellite positioning and navigation systems to support a correct farm management realizing solutions able to interact between management informatic systems (MIS) and mobile process systems (MPS). All the above, in view of a robotization of various operations governed by DGPS.

The papers presented by the manufacturers are enlightening about it, giving the possibility to appreciate the efforts carried out as well as the future subjects of development based on solutions more and more integrated in order to improve equipment performances and to reduce workers tiredness. All this, recognizing that there is some difficulty in offering the various innovations to the end users.

In conclusion, the participants **unanimously recommend** to carry out every effort for the development — within a strict co-operation between industry and research bodies — of few subjects particularly concerning: sensors and actuators linked to precision farming able to work in real time and decision support systems able for a better monitoring and governing various agricultural processes. This defining at the same time international standards on the various technologies and systems as, for example: diagnostics system, universal interfaces to GIS, high performance BUS systems consistent with the existing mechanical solutions, limitation of electromagnetic emissions etc.

Nevertheless, in order to give these innovations the possibility to reach the operational and technical goals for which have been realized, it is necessary to develop a great spreading and demonstration activity and, at the same time, to verify the real economic advantage of their introduction.

Finally, the participants **underline the importance** — for a rational use of machines — to improve the tractor implement combination (BUS systems), incorporating the respect of safety measures, as well as decisional goals able to promote the use of tractors and implements within a complete environment protection.

3 - EUTRAC: MSc in European Agricultural Engineering

On the basis of a short introductory presentation by *N. Warner* (UK) and *R. Ramharter* (Austria) the participants **unanimously express their approval** to the multinational cooperation programme promoted by the Royal Agricultural College of Cirencester (UK) and involving the Institutes of Agricultural Engineering, of the Universities of Hohenheim (Germany), Milano (Italy) and Wien (Austria).

Scope of the 2-years long course is to produce agricultural engineers with a knowledge of the industrial sector of almost 2 EU countries selected between the 4 above mentioned in order to acquire a Postgraduate certificate in European Agricultural Engineering awarded and validated by the Royal Agricultural College of Cirencester.

After a deep discussion, the participants **recommend** the enlargement of the programme to other European Countries and the assumption of future post-graduates from the agricultural machinery industry. The problem will be re-examined in one of the next Club's meetings.

Report from EIMA '97 — EIMA 28, Communique No. 11, Rome, November 1997

The balance-sheet for the 28th edition of EIMA, the international machinery fair organized by Unacoma Service with Bologna Fiera in Bologna on October 29-November 2.

The figures alone tell the tale: 1 470 exhibitors of whom 357 from 36 foreign countries showing a total of 17 500 models of machinery and equipment falling into 14 sectors and covering almost 1 000 product groups in the official catalogues. This vast range of machinery for agriculture, agro-industry, animal husbandry and gardening, forming one of the most important fairs of its kind in the world, covered 110 000 sq.m. (compared to 104 000 last year) in 20 covered and climatised pavilions vistited by over 110 000, a record for the event.

The number of manufacturers taking part also shows how active this sector of the Italian machine industry is. This year's figures for output and turnover remain good. According to figures released by Unacoma's chairman, Aproniano Tassinari, on Octorber 28, Italian makers of farm, gardening and earth-moving machinery expect to end 1997 with total turnover of 15 000 billion lire (14 511 in 1996) of which 8 300 billion from exports to give a trading surplus of 6 300 billion. Tractors account fort 5 600 billion, and other agricultural machines (including engines, parts and gardening machines) about the same for a total of 11 200 billion; earth-moving machinery accounts for about 3 800 billion.

In terms of output produced, 1997 is expected to finish with 363 000 tons of tractors, incomplete tractors and parts and 495 000 tons of other agricultural machines for a total of 885 000 tons, only 0.6% less than in 1996 when the total of 863 400 tons set an all-time record for Italian manufacturers. This edition of the EIMA fair is also one of the most interesting ever organized for its technical, cultural and, in a broad sense, political offerings. The announcements, meetings and debates marking the fair pointed to further product innovation, a special attention for foreign markets, the search for closer harmony between agricultural and environmental policy, and of these two with the expectations of the farmers.

The exhibition of technical novelties, assessed and awarded prizes by a jury of experts, was a chance for all professionals to get an update. It also provided an effectiver promotional vehicle for the large number of visitors who crowded into the area of the Fair set aside for the ten machines during their trials. On commercial strategies, EIMA '97 could not fail to stress Italian industry's inclination for foreign markets which already absorb 60% of production and represent an increasingly vast and interesting area for trade. This was confirmed indirectly by the presence of thirty official delegations from countries in every continent, up by 66% on 1996.

Special attention was paid to openings for cooperation with countries of the Near East. Italo-Arab Day stressed the need to develop and modernize irrigation systems for intensive crops. An idea for hte creation of an Italo-Arab agrarian training institute and a system of specialization scholarships also won approval. The event, organized by Unacoma, was attended by Unacoma's honorary president Alfredo Celli, businessman Renato Cifarelli, Simest's Giancarlo Bertoni, the director of the Inter-Arab Organization for Agricultural Development Yahya Bakour, Mohammad Rachid Quambar of the Italo-Arab Centre for Development in Arid and Desert Zones, and the director of the Dubai Chamber of Commerce, Sultan Al Mansoor.

A wide-ranging assessment of the problems and prospects for agricultural mechanization in agricultural development processes in various parts of the world was also made by the Club of Bologna, the association promoted by Unacoma. Chaired by Prof. Giuseppe Pellizzi, the club's membership now includes lecturers, researchers and industrialists from 44 countries. The issue on the agenda this year were the role of sub-contracting in bringing new productivity-increasing machines to various field operations and what research and industry have to say about the role of electronics and decision support systems in the new phase of mechanization.

Dr. A.K. Mahapatra, a co-editor in Zambia moved to Botswana

Dr. A.K. Mahapatra has joined the Botswana College of Agriculture, Dept. of Agricultural Engineering and Land Planning since July, 1997. He will serve as a co-editor of AMA in Botswana hereafter. ■■

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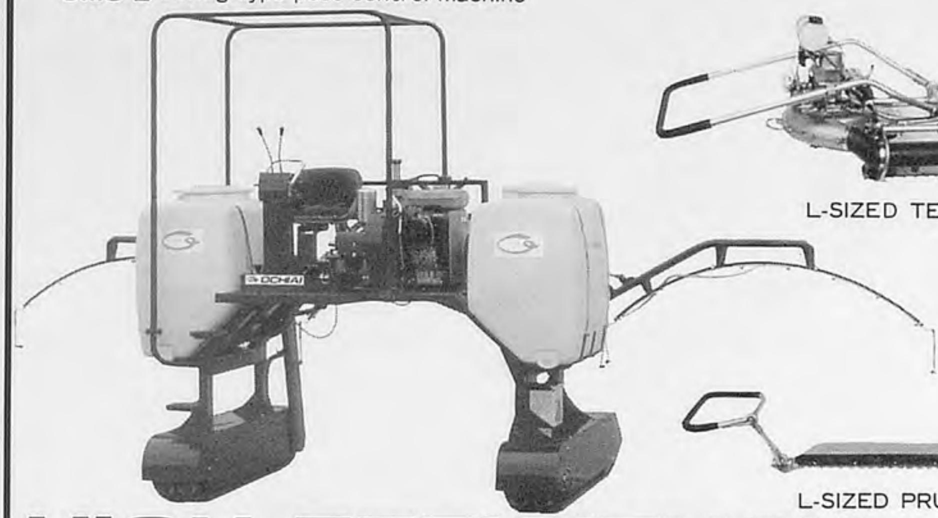

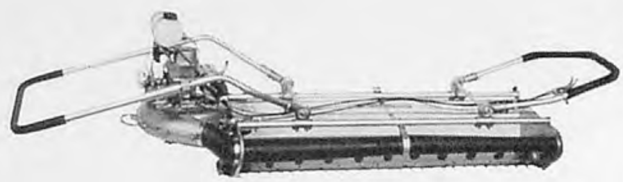

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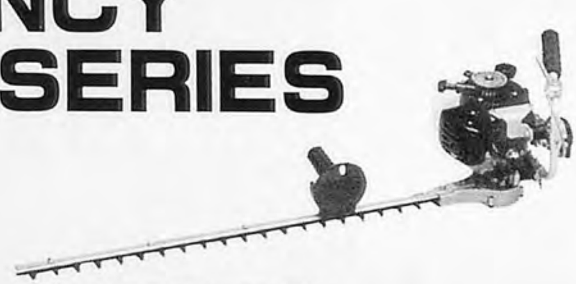

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