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Edited by

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EDITORIAL

Two Steps Forward, One Step Backward

The year 2004 was ushered in with merriment and optimism in many parts of the world but not quite true in Iraq and Afghanistan. In these countries the post-war shadow of the war continues to exact turmoil and confusion bred by the insurgent's nefarious activities that spell hardships for the spoils of the war.

To say nothing of the loss of hundreds of lives in the military and insurgents themselves, this deplorable situation is unquestionably an offshoot and residue of the wars that brought the downfall of Saddam Hussein and his cohorts and that of the Talibans. But more glaring perhaps which the media hardly cite is the untold destruction in both commercial agricultural infrastructures and institutions. For some more time to come, this destruction will jeopardize the future of agricultural resources in the meanwhile that the hapless victims of the hostilities continue to suffer.

One begins to wonder if there is any similarity between the drawbacks in agriculture and the harm inflicted during and after the war, on the one hand, and the catchword two-steps-forward and one-step-backward in relation to farming. What modest advances in farming the farmers in Iraq and Afghanistan have made will return them to square one or one step behind. Until and unless the farmers are able to harness the potential of farm mechanization, the prospect of increased productivity is nil.

In a related but global perspective, the race vs. population and food production continue unabated. Population explosion is winning judging from a recent that 2.4 babies are born per second. In contrast, food production is still unable to provide adequate food for the teeming millions in developing and underdeveloped countries. Even the People's Republic of China has recently found the need to import food into the country.

AMA is not about ready to apologize that, but by reliable reckoning, sufficient mechanization of farmlands has not been progressing in developing countries. And yet it is commonly recognized that mechanization is indispensable in performing timely farm operations with its concomitant productivity increases. AMA is not backing down but will instead continue to play up the fact that truly, there is a real need to advance the cause of farm mechanization even on a step-by-step procedure that should yield initially even in small quantities of much needed food. In time, as successful farmers have experienced, production has improved for them at comfortable levels.

To all AMA readers, AMA says, let there be no more wars! Instead, let there be modern plows and efficient tractors to till the land in the place of guns and tanks that destroy precious lives and properties!

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January 2004

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Determining Soil Inversion Tillage Interval in Rice Production

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Abstract

Five years' soil inversion tillage interval in rice production was evaluated during 1994 to 1999. Soil inversion residual effect was found lasting three years at significant level. Every year soil inversion continuously registered the highest yield and contributed the highest increase of 27.99% in net return and cost-benefit ratio of 2.40 which proved to be the best tillage interval in rice production.

Introduction

Rice is the second food grain and third major crop in Pakistan. It is a crop of irrigated areas and grown on about 10% of the total cultivated land. Soil in rice fields varies from loam to clay loam. Ecologically, only one crop of transplanted rice is cultivated in the country spanning last week of June to November. Rice-wheat is the main crop rotation in the area.

The most common mechanical package in vogue is to prepare land while dry with 2 to 4 plowings followed by puddling with a cultivator used twice or thrice. While puddling, a plank is attached to the cultivator in its last operation to accomplish leveling. Compared with conventional tillage, significant increase in paddy yield was observed with complete soil inversion using once mold board plow (M.B.Plow) as prepuddling tillage followed by puddling twice with plow. The package was found economically viable (Razzaq et al 1993). This technology package was transmitted to farms through the Training and Visit (TV) agricultural extension system observed in the country. Institutionally, improved implements, including M.B.Plow, valued in millions, were given to farmers at 50% subsidy during the early 90s under a project entitled On Adoption. Farmers raised questions about the interval of using M.B.Plow in rice production. The present study was arranged to satisfy feed back. On topic, no early study is available peculiar to rice culture in Pakistan. The study is quite original in nature.

Materials and Methods

The study was conducted to evaluate the effect of a five-year soil inversion tillage interval on rice fine variety, B-385, in clay loam soil at an adaptive research farm in Sheikhukpura. The study was completed in six years starting from 1994 to 1999. Trials were laid out in randomized complete block design with 3 replications at the same site every year. The following treatments were tested:

1. Conventional tillage
   Prepuddling; cultivator, thrice+puddling
   Cultivator, twice and planking, once-check
2. Soil inversion:
   Prepuddling; M.B.Plow, once+puddling;
   Cultivator, twice and planking, once in a 5-year cycle.

Soil inversion cycle comprising of every year(Y1),2 years (Y2),3 years (Y3),and 4 years (Y4) and 5 years (Y5) intervals was completed in six years as matrixes below:

1994	1995	1996	1997	1998	1999
Y1	Y1	Y1	Y1	Y1	Y1
Y2		Y2		Y2	
Y3			Y3		
Y4				Y4	
Y5					Y5

Plot not tilled with M.B.Plow were conventionally prepared.

The implements were run with 75 H.P. MF-375 tractor. Prepuddlingt treatments were carried out at plough able moisture. Soil was inverted with M.B.Plow after the harvesting of wheat and left to weather for two months before puddling. Rice seedlings were manually transplanted. All the agronomic and plant protection measures were uniformly adopted as per agricultural departmental recommendations. Yield data were recorded, averaged on yearly basis and *percent increase over the conventional practices were calculated. Every year, statistical analysis was undertaken to ascertain significant difference between treatment means at 5% level and least significant diffence(LSD) computed. Economic analysis was undertaken on the basis of a 6-year average paddy yield using paddy support price of Rs.400 per 40 kg fixed by the Government and the market prevailing input rates during 1999,i.e., last year of study.

Results and Discussion

The effect of soil inversion interval on paddy yield is shown in **Table 1**. During the 1st year of study, i.e., 1994, although all five treatments of soil inversion tillage registered higher paddy yield than conventional tillage, their means difference were statistically found insignificant. Compared to conventional tillage, significantly different paddy yield was observed against Y1, Y2, Y3, Y4 and Y5 during 1995. Maximum increase of 12% in paddy yield was reaped under every year soil inversion, i.e., Y1. The quantum of increases of paddy yield against Y2, Y3, Y4 and Y5 was also higher than of 1994, which signified soil inversion residual improvement of the profile. However, there was insignificant paddy yield difference between means of Y1, Y2, Y3, Y4 and Y5. Similar results were obtained during 3rd year i.e., 1996.

Treatments behaved differently during 1997, i.e; 4th year. Every year soil inversion (Y1) resulted in highest paddy yield of 3275 kg/ha with an increase of 16.96% over that of the check which was significantly different from all other treatments' means. Inspite of the fact that the quantum of increases in paddy yield in Y4 and Y5 comparatively declined it was still significantly different and higher than check which expressed a significant residuality of soil inversion. Soil inversion carried out with 3 years interval, i.e., Y3 showed positive trend in combination with the residual response by increasing paddy yield to 11.61% next to Y1 which was significantly different from the means of Y4, check and Y5. Treatment Y2 where no soil inversion was undertaken during 1997 gave significantly different paddy yield from the check and insignificant from Y3, Y4 and Y5 with an increase of 9.82% showing favorable residual effect.

In 1998, paddy yield continued increasing under Y1, i.e., every year soil inversion. This treatment contributed significantly different and the highest paddy yield of 3208 kg/ha with an increase of 22.21% over check. Next to it, insignificantly different paddy yields with an increase of 14.28, 11.12 and 9.52%, although significantly different from Y1, Y2 and check, were obtained with Y2, Y3 and Y4, respectively, which exhibited positive response to soil inversion in combination with its residuality. Paddy yield against Y5 reduced to the level of insignificant difference from the check and eliminated residual effect of soil inversion.

During 6th year, i.e., 1999, paddy yield results synonymous to 1998

Table 1. Effect of Soil Inversion Tillage Interval on Paddy Yearly Average Paddy Yield

	1994		1995		1996		1997		1998		1999	
Treatments	kg/ha	%inc.	kg/ha.	%inc.	kg./ha.	%inc.	kg./ha.	%inc.	kg./ha.	%inc.	kg./ha.	%inc.
T1=Conv.tillag	4562	--	4485c	--	3450c	--	2800c	--	2625c	--	3255c	--
T2=Soil invers.												
Y1	4958	8.68	5023ab	12	3883ab	12.55	3275a	16.96	3208a	22.21	3667a	12.66
Y2	4750	4.12	4904b	9.34	3800b	10.14	3075cbd	9.82	3000b	14.28	3468b	6.54
Y3	4771	4.58	4884b	8.9	3750b	8.69	3125b	11.61	2917b	11.12	3440b	5.68
Y4	4895	7.3	4943b	10.21	3766b	9.16	3000	7.14	2875b	9.52	3457b	6.20
Y5	4771	4.58	4904b	9.34	3778b	9.51	2965d	5.89	2805c	6.86	3282c	0.83
	NS		LSD=384		LSD=267		LSD=121		LSD=205		LSD=148	

Soil inverted with M.B. Plow
*=percent increase.

Table 2. Economic Analysis

Treatment	Overall average paddy yield kg/ha.	% increase	Gross exp. Rs./ha.	Gross income Rs./ha.	Net return % increase	Cost-benefit Ratio
Conventional tillage-check	3529	--	17065	35290	--	2.07
Soil inversion:						
Y1	4002	13.4	16694	40020	27.99	2.4
Y2	3833	8.61	16880	38330	17.70	2.27
Y3	3814	8.08	16941	38140	16.32	2.25
Y4	3823	8.33	16941	38230	16.81	2.26
Y5	3751	6.29	N.A.	37510	12.86	2.21

were obtained. Insignificantly different paddy yield with soil inversion interval of 5 years, i.e., Y5 from the check reverted results to the behaviour observed during 1994 and testified continuity of its residual effect up to 3 years, i.e., 1997. Insignificant yield differences between Y2, Y3 and Y4 but significantly different from the check and Y1 showed positive response to the combination of soil inversion and its subsequent residual in the cycle. Jointly examining the results against Y4 and Y5 during 1998 and 1999 where paddy yield was found increasing and insignificantly attaching to Y2 and Y3 in the former and declining and insignificantly combining with the check in the latter also inferred significant combining with the check in the latter also inferred significant residuality up to 1997. Similar to previous years, every year soil inversion i.e., Y1 recorded the highest and significantly different paddy yield with an increase of 12.66% over the check.

Table 2 presents on economic analysis of the study. In the over-all average of 6 years, every year soil inversion increased paddy yield by 13.40% over the check. Next to it, almost a uniform increase in yield ranging between 8.08 to 8.61% was obtained against 2, 3 and 4 years interval of soil inversion. Soil inversion interval of 5 years gave 6.29% increase of paddy yield over the check. As is evident from **Table 2**, every year soil inversion technology was found the cheapest, generating the highest income. As a result, the highest increase of 276.99% in net return, contributing the best cost-benefit ratio of 2.40 and proved to be the most economically viable package. Evaluating economic parameters, alternate year soil inversion was observed as the next best treatment giving 17.70% increase in net return and cost-benefit ratio of 2.27 with marginal edge over 3 and 4 years intervals. Comparatively, soil inversion interval of 5 years was rated at the bottom in economic performance as it contributed 12.86% increase in net return over the check and cost-benefit ratio of 2.21.

Reviewing **Table 1**, the prevalence of insignificant paddy yield difference between soil inversion intervals up to 1996 and shooting up of Y1 in 1997, cursorily, inferred to use M.B.Plow after 3 years. But continuity of the significantly higher paddy yield from 1997 onward under every year soil inversion and failure of other intervals to maintain parallel increase omitted prior inference. Juxtaposing economic analysis, **Table 2**, with **Table 1**, being cheaper by cost and contributing the highest increase in net return and the best cost-benefit ratio, every year soil inversion was found befitting rice production in rice-wheat cropping system.

Conclusion

1. Instantly, soil inversion increases paddy yield in clay loam soil but it is insignificantly different from conventional tillage with the plow in total.
2. Residual improvement of soil inversion progresses to significant level and lasts up to 3 years.
3. Contributing the highest paddy yield continuously and proving economically viable by generating the highest increase of 27.99% in net return and cost-benefit ratio of 2.40, every year soil inversion is the best tillage interval in rice production.

REFERENCE

Razzaq, A., B.A. Sabir & A.Karim. 1993. Effect of soil inversion tillage practices on rice production. Agricultural Mechanization in Asia, Africa & Latin America (AMA), Japan, Vol.24, No.2:13-16.

■■

An Opto-electronic System for Assessing Seed Drop Spacing of Planters

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Abstract

The assessment of plant spacing as provided by mechanical planters is crucial in analyzing their performance. A computerized opto-electronic seed spacing measurement system was developed to rapidly determine the time intervals between seed drop events. It used a photo detector along with allied circuitry and a computer interface. By detecting the seed drop events at the seed tube end, it measured the time interval between the seed drops. The time interval multiplied by the planter's travel speed gave an estimate of the seed spacing. Using the developed system, a cup feed seeder was evaluated for its plant spacing on-the-row. The seed spacing data was acquired at operating speeds of 1.5, 1.75, 2.0 and 2.25 km h^{-1} for metering groundnut, maize, sorghum, green gram and black gram. Frequencies of spacing occurrences were plotted as histograms. The peak percentile frequency for black gram, green gram, and sorghum was around 45 to 50 per cent at very low spacing of 2 – 4 cm, indicating predominant occurrence of multiples. Maize and groundnut seeds indicated lesser incidence of multiples at about 20 to 30 per cent. An analysis of variance on the frequency plots as quantified by an index for each, indicated that the type of seed is highly significant on cup feed seeder performance and speed is insignificant These trials on the commonly used seeder proved the capability of the developed system in assessing the performance of any given seeder.

Introduction

Seed drills and planters are the most important farm equipment in mechanized farming because all post planting operations depend on proper crop geometry. The function of these machines is to meter seeds without damage at the desired rate and place them uniformly at desired depth and spacing, with the furrow covered and compacted as desired. Proper placement of seed is necessary for a perfect crop stand. Uniform plant spacing is very important for all crops, because it affects the production cost and crop yield. This is particularly true for those commercial crops, whose seeds are expensive. Uniform crop stand implies equal nutrient uptake, thus helping the plants to attain same characteristics such as root thickness, stem diameter, etc. This in turn provides efficient post planting operations.

The assessment of plant spacing as provided by the planters is hence crucial in analyzing their performance. A variety of methods have been evolved so far to assess the plant spacing offered by planters. Measuring the spacing between germinated plants after sowing with the machine, is the most common method. This method's accuracy is seriously affected by the quality of seed bed, weather conditions and more importantly by seed viability. It is hence difficult to segregate the planters' performance from these effects. Moreover, drop errors and scattering errors due to seed impinging on the soil, affect the spacing and are not discernable by this method.

The second most prevalently used method is the greased belt test, which is better in terms of its non-dependency on crop and field characteristics, and the minimized scattering losses due to the presence of grease. But the limitations are the belt's length, the need for tediously measuring the spacing between seeds on the belt and the chances of seed dislocation when belt speed is high. So there has been a search for an alternative method for assessing the plant spacing offered by planters.

Chinnan *et.al.,* (1975) studied the accuracy of seed spacing in peanut planting, by conducting two different types of laboratory tests, namely "photo-diode experiment' and "belt experiment". They evaluated the overall performance of the planter and concluded that the photo-diode experiment could assess spacing inaccuracies more precisely than the latter. Kocher *et.al.,* (1998) and Lan *et.al.,* (1999) developed an opto-electronic seed spacing evaluation systems that measured time intervals between the seeds and detected front-to-back location of seed drop events relative to the planter towards rapidly determining seed spacing uniformity in the laboratory. They used a seed detection sensor consisting of a rectangular photogate with 24 phototransistors receiving light beams from LEDs opposite them. The measurements obtained based on time intervals between seed drop events were strongly correlated with the measurements obtained using a greased belt stand. The objective of this study was to develop and test a simpler opto-electronic system for measuring the spacing offered by a planter.

Materials and Methods

a. Concept of opto-electronic sensing system

Seeds passing between a constant light source and an opto-electronic detector, block the light to change the detector's output sufficiently enough that an electronic circuit can recognize the seed passage. A phototransistor was used along with allied circuitry and computer interface. By detecting the seed drop events at the seed tube end, it measured the time interval between the seed drops. The time interval multiplied by the seeder travel speed gave an estimate of the seed spacing. A comparison of the raw time intervals between subsequent drops was a measure of the spacing uniformity.

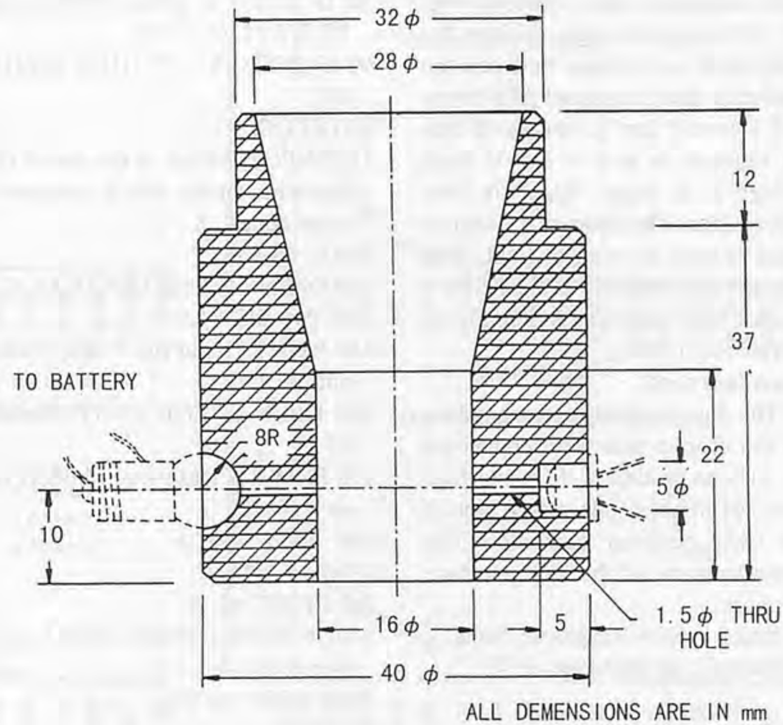

Fig.1 Optical sensing unit.

b.Constructional features of the opto-electronic system

The opto-electronic system consisted of a photoelectric transducer, a constant light source, allied digital circuitry and a digital I/O card coupled to a personal computer. A computer routine assessed the time intervals between the drop events.

Optical detector assembly

A nylon round of 40 mm diameter was machined to have a funnel shaped hole (**Fig. 1**). This receptacle was inserted on the bottom end of the seed tube so that the seeds received were lead through it. At the bottom end of this receptacle, a hole of diameter 2.5 mm was drilled radially, such that it was perpendicular to the longitudinal axis of the tube. One end of the hole was fitted with a photoelectric transducer and the other end with a constant light source of a 1.8 V, 0.5 W. bulb connected to a 1.5 V cell. The bulb was fixed to the mount such that the light beam could traverse and fall on the photoelectric transducer through the radially drilled hole without much scattering.

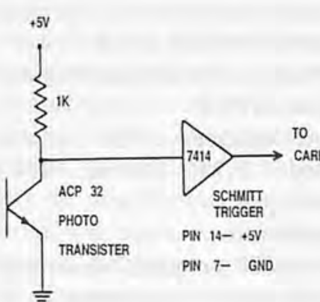

Fig.2 Optical sensor circuit.

The heart of the detecting system was a phototransistor (ACP 32) with necessary load resistors (**Fig. 2**). Whenever the light falls on the transistor, the voltage between the collector and the ground falls below 0.5 V level ("low"), whereas at other times it is at a > 4.5 V level ("high"). A logic "high" is produced from the transistor, when a seed crosses the path of light. This signal from transistor is cleaned to a square logic signal by a Schmitt inverter chip (7414).

Interface card

The digital signals corresponding to the drop events were connected in turn to a digital I/O interface card, as inserted into a free slot of an IBM personal computer. The specifications of the I/O interface card are:

Make : ESA Bangalore, India
Model : 48 DIO ESA.

Features :
PPI ICS - 8255 INTEL (2 nos)
48 I/O digital lines
Buffered address bus
Parallel post address of computer selected by DIP switch
24 lines on D connector and 24 lines on FRC
Port addresses of the computer used : 387 H – control; 384 H – 'A' port

The software

A BASIC program, whose code is given below, was written to assess the seed drop events.

```
10  REM For assessing the delay
    between seed events and deter-
    mining the seed spacing
15  CLS
20  OUT &H387, &H99: 'com-
    mand word for interface card
    8255 ports-a in,b out
30  INPUT: "Feed the file name for
    storing the delay data; FIL$
35  PRINT: "Press any key to stop
    acquiring data"
40  OPEN FIL$ FOR OUTPUT AS
    #1: 'Open a output data file
50 REM  Routine for inputting data
    thru interface card
60 X% = INP(&H384)
70 C = C + 1
80 IF X% = 0 THEN PRINT C:
    PRINT #1, C: C = 0
90 IF INKEY$ = "" THEN GOTO
    60
100 CLOSE #1
110 INPUT "What is the speed of
    operation under which measure-
    ment done "; S
120 S = S / 36
130 OPEN fil$ FOR INPUT AS #1
140  f$ = fil$ + ".txt"
150 PRINT "Input file "; fil$, "Out-
    put file "; f$
160 OPEN f$ FOR OUTPUT AS
    #2
170 PRINT "Please wait, process is
    on"
180  INPUT #1, A
190 A = A * S
200 PRINT #2, A
210 IF EOF(1) THEN GOTO 220
    ELSE 180
220 CLOSE #1, #2
230 END
```

The program first initializes the 'A' port into an input port through invoking the interface card's control port. The digital input from the opto-electronic sensor was connected to the "0^{th} " bit of the port 'A'. Since the chip 7414 is an inverter, a logic "high" exists on its output, when the light is not interrupted by the seed. The programme cycling through a loop, assesses whether the bit '0' of port 'A' jumps to "low". The number of cycles made is counted by initializing a counter. When the detector detects a seed passing through the tube end, the signal goes "low" detecting the seed. Immediately the count (the delay between two subsequent seed events) is written to a data file. The counter is immediately reset and the program waits for the next seed event to happen. In effect, the system counts out the delay between subsequent seed drops and stores it in a disc file. Each count on the counter corresponded to 1 millisecond (ms) delay as found from the calibration of the program. This implied that the number of counts could be taken to be the mean delay, between seed drop events. By knowing the speed of operation of the planter, the spacing between the seeds in a row was calculated as a product of the time duration between two seed events (ms) and the speed of operation (km h^{-1}). The program converted the recorded time duration between the two seed events to corresponding distance, which is the spacing between two consecutive seeds.

Laboratory Tests on-the-row Plant Spacing

A cup feed seed metering device was evaluated for its plant spacing on-the-row, using the developed system. It was coupled to a mechanized variable speed drive so that its metering shaft could be driven at rotary speeds corresponding to different forward speeds of travel. The experiment with optical sensor was effected on different types of seeds, namely; groundnut, maize, sorghum, green gram and black gram. The time interval between seed drop events was recorded at each operating speed of 1.5, 1.75, 2.0 and 2.25 km h^{-1} and then converted to corresponding seed spacing on-the-row. Based on the obtained readings, frequency distributions of spacing occurrence at increments of 2 cm spacing, were made. But since the total number of events for each replicated trial could not be constant, these distributions were normalized in terms of percentage of total events, providing the possibility of comparing the frequency distributions of different seeds and speeds.

Results and Discussion

Effect of Travel Speed on The Frequency Distribution

The spacing occurrence distribution of metering different seeds is summarized in **Figs 3 to 6**.

Generally the effect of speed on the obtained spacing was not pro-

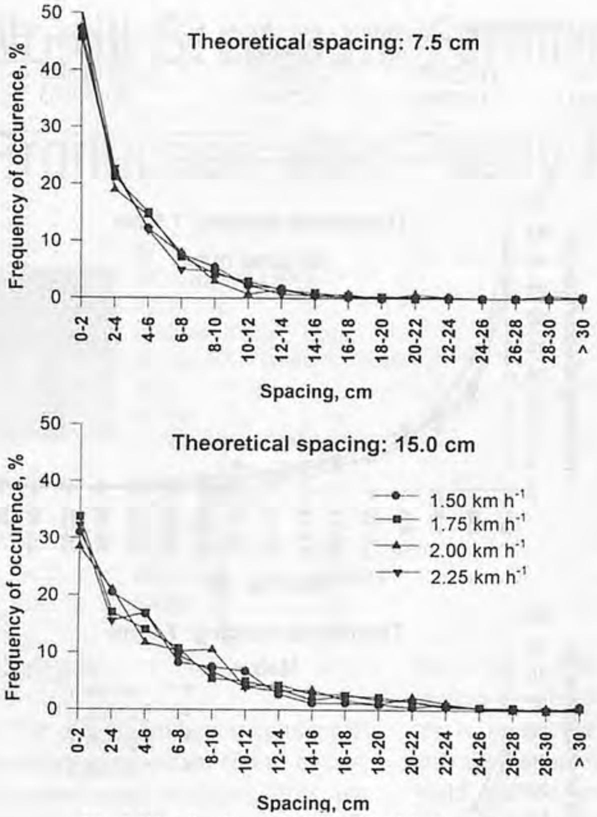

Fig.3 Distribution of spacing for black gram.

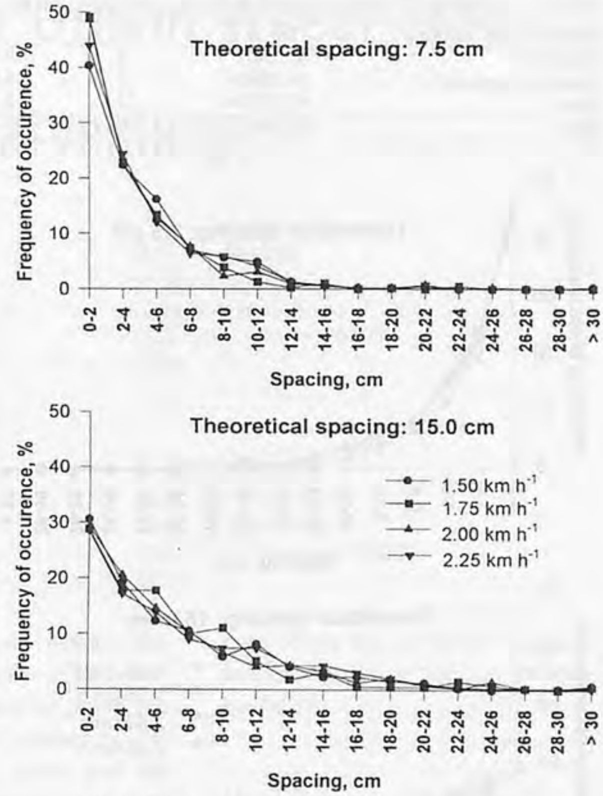

Fig.4 Distribution of Spacing for green gram.

nounced in all the types of seeds metered by the cup feed mechanism. This was indicated by the distributions pertaining to different seed types overlapping one another. However, in maize (**Fig. 6**), the effect of speed was slightly indicated in the occurrence of multiples. That too, no definite trend in relationship between the speed and spacing frequency was observed.

Effect of Seed Type on the Frequency Distribution

In all the distributions, the frequency was always higher for lower spacing ranges, which declined as the spacing increased. The peak percentile frequency for black gram, green gram, and sorghum (**Figs. 3, 4 and 5**) was around 45 to 50 per cent, although theoretically the cup spacing versus ground wheel rotation should have given a theoretical spacing of 7.5 cm. The frequency at that range was very meager (5 to 10 per cent) for all the types of seeds. The frequencies in these cases became almost close to null at a spacing of 12 to 14 cm. This clearly indicated that the inertia of the rotating cups caused a higher range of multiple pickups and thereby provided lower spacing than the desired.

As for large seeds like maize and groundnut (**Fig. 6**), the picture was different that the low spacing caused by multiples, occurred less frequently (20 - 30 %) and the frequencies of occurrence were nil at about 16 to 18 cm in groundnut and 22 to 24 cm in maize. Maize being flat, the orientation in which the pick up made was crucial. The distribution curve observed had low slope in contrast to any other types of seed.

Effect of the number of cups on the frequency distribution

In three types of seed, namely; black gram, green gram, and sorghum (**Figs. 3, 4 and 5**), the alternate cups on the rotor were blocked, so that the desired theoretical spacing on the row could be increased from 7.5 cm to 15 cm. The optical sensor experiments were carried out with this arrangement. But the peak frequency of occurrence was again not found at the desired theoretical spacing of 15 cm. Comparing the frequency distributions of the rotor giving 7.5 cm theoretical spacing against that giving 15 cm spacing, the general observation was that the occurrence of multiples drastically reduced by half.

A statistical test was attempted to compare distributions of the seed spacing occurrence obtained from the optical event detection equipment. A comparison of distributions required a sound index, which would quantify each distribution as such. Since the distributions were already normalized into percentile values, an index was formulated in the form:

$$I = w_1 x_1 + w_2 x_2 + w_3 x_3 \ldots\ldots$$

Table 1. ANOVA on Influence of Seed Type and Speed on Spacing Distribution

Source of Variation	SS	Df	MS	F	P-value	F crit
Seed type	583.2707	4	145.8177	43.4207**	4.8E-07	3.259160053
Speed of operation	14.86964	3	4.956547	1.47593	0.27062	3.490299605
Error	40.29896	12	3.358247	---	---	---
Total	638.4393	19	---	---	---	---

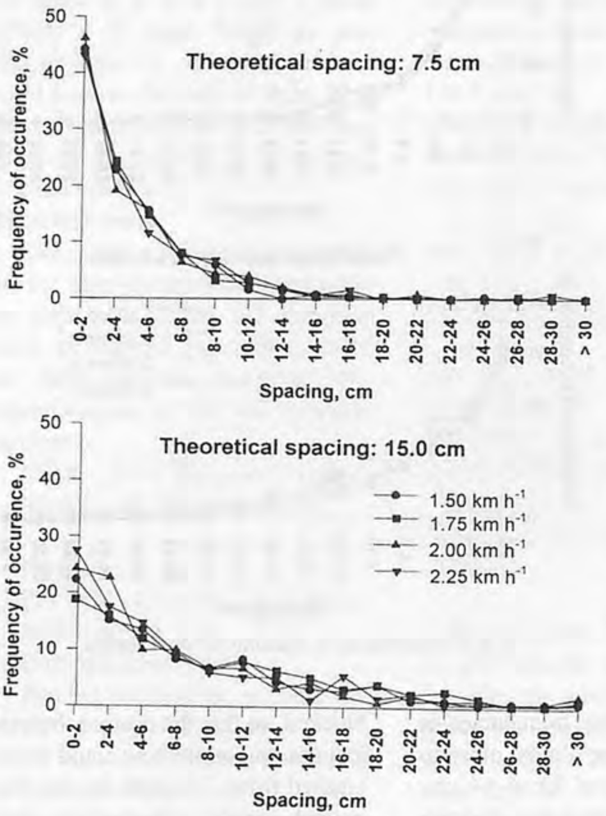

Fig.5 Distribution of Spacing for Sorghum

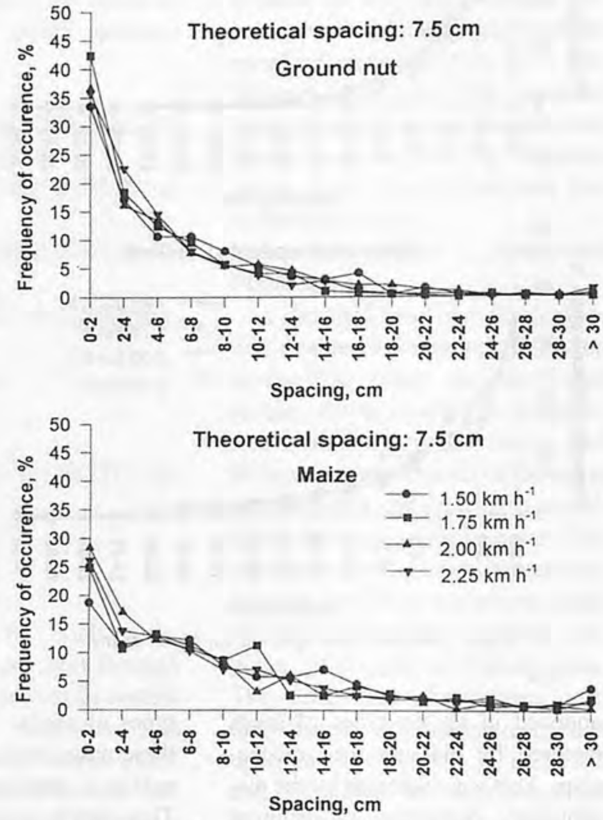

Fig.6 Distribution of Spacing for Large Seeds

where, x_1, x_2, ... are the percentile occurrence frequencies of each spacing and

w_1, w_2, ... are incremental weights at a step of unity.

This expression was applied to each of the distribution of spacing occurrence to obtain a single quantification. These indices naturally quantified both the rise and spread of the distribution and were relative quantifications of the distributions. Having done this, analysis of variance was done on these with the type of seed and the speed of operation as factors. The analysis of variance (**Table 1**) indicated that the type of seed is highly significant on the frequency distribution. This implies that each type of seed as affected by its distinct shape and size and also by the seed cup's configuration, was proven highly significant. The speed of operation was insignificantly affecting the distributions.

The trials on the commonly used cup feed seeder hence proved the capability of the developed opto-electronic system to assess its performance.

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No-till Seed-cum Fertilizer Drill in Wheat Crop Production after Paddy Harvesting

by

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Abstract

The present study was conducted to evaluate the effect of use of no-till seed cum fertilizer drill on wheat crop yield, energy input, soil health and cost of operation in comparison with the conventional seed drill. The no-till seed drill has resulted in a 17.09% increase in yield, 83.22% savings in energy and 80.34% savings in the cost of production. There was no appreciable effect of no-tillage system on bulk density and shear strength of the soil below ploughing depth (25-30 cm). The overall benefit was Rs. 2140.33 per hectare. Moreover, the advantage of early sowing is obvious. Moisture retention and moisture depletion were high in no-tillage system during stress periods.

Introduction

India is predominately an agricultural country. Agriculture is the most important sector of the Indian economy both in terms of gross national product and number of productive workers employed. With the introduction of high yielding varieties of wheat, chemical fertilizers and mechanization of agriculture, the yield of wheat has increased considerably. The country is producing surplus food but still the potential of increasing the yield of food grain exists and net returns obtained by rural peasantry can be raised by reducing the tillage cost. Timeliness is important in sowing wheat crop. Sharma *et al.* (1984) indicated a reduction of about 35-40 kg/ha/day in the grain yield of wheat crop under delayed sowing. Similar results were observed by Hobbs(1995). There may be several reasons for delayed sowing, of which the main reason is excessive tillage operations required for field preparation in paddy production.

The paddy-wheat cropping system applied over an area of about 9.50 lakh hectares in Haryana State (1997-98) faces an epidemic problem of *Phalaris Minor weed.* This weed reduces the use efficiency of costly inputs due to which productivity is adversely affected. The use of no-till drill can take care of this problem because the unploughed area does not allow the germination of weed seed before the germination of the wheat crop is established. This study estimated the higher wheat yield, savings in energy, cost of sowing and cost-benefit ratio of the use of no-till seed-cum fertilizer drill over the conventional seed drill.

Materials and Methods

The study was conducted at Krishi Vigyan Kendra, Kaithal district of Haryana State in India. The objective was to determine the prospect of use of no-till seed-cum fertilizer drill on crop yield, soil health, energy input and cost of operation in wheat crop. After harvesting the transplanted paddy, the wheat was sown directly in a plot without tillage operation by no-till seed-cum fertilizer drill. In another plot, the wheat was sown by conventional drill (3-times harrowing + 2-times planking + sowing with drill). The trial was repeated three times to get replicated observa-

Fig. 1 Field evaluation of no-till seed fertilizer drill.

Table 1. Bulk dEnsity of Soil at Sowing Time

Depth (cm.)	Bulk Density (gm./ cu. cm.)	
	No-till system	Conventional system
0-10	1.69	1.58
10-20	1.72	1.65
20-30	1.73	1.69
30-40	1.71	1.70
Mean	1.71	1.65
S. D. *	0.02	0.05

Table 2. Soil Moisture During Wheat Growing Season

Depth (cm.)	Sowing time		85 days after sowing		Harvest time	
	N.T.*	C.T.*	N.T.	C.T.	N.T.	C.T.
0-10	23.70	21.90	21.30	21.70	17.10	15.30
10-20	22.10	21.20	19.10	19.80	17.30	17.20
20-30	22.70	21.40	19.70	19.90	16.90	18.10
30-40	22.30	21.20	20.50	20.20	16.60	18.30
40-50	23.20	20.00	21.10	20.30	17.50	19.20
Mean	22.80	21.14	20.34	20.38	17.08	17.62
S. D. **	0.58	0.62	0.83	0.68	0.81	1.32
C. V. **	2.57	2.95	4.09	3.36	1.82	7.50

* N. T. for the No-tillage and C. T. for the conventional tillage.

tions. All inputs, except the method of sowing were similar for all plots. The variety of wheat used for the study was UP-2338.

The machine has a provision of nine lines. The depth is controlled by two depth control wheels provided at the side of machine. Adjustment was provided to vary the spacing between two furrow openers. The quantity of fertilizer is regulated by meshing the diamond-shaped holes provided in the bottom. Star-type agitators were provided to avoid the bridging of fertilizer in the box. There is a provision of split type fluted rollers in the chamber of seed for regulating the quantity of seed being dropped. The specifications of the seed-cum fertilizer drill were as follows:

M. S. frame: 184 × 61 cm. rectangular

Seed cum fertilizer box: 145 × 52 cm. with two compartments, one for seed other for fertilizer.

Furrow openers: Inverted T-type attached to frame by nuts and bolts.

Seed metering mechanism: Split type fluted roller.

Fertilizer metering mechanism: Hole mesh type.

Power transmission: Power transmission from ground wheel to seed metering shaft through chain sprocket system.

The detailed observations of soil parameters such as moisture content, bulk density, soil texture, clod mean weight diameter, shear strength, infiltration rate etc. were determined as per standard procedure.

Yield and its attributing data were also recorded.

Results and Discussion

Effect of tillage on bulk density of soil

On the basis of composition, the soil was observed to be silty clay. The bulk density of the soil in no-till system was greater than that of the conventional method up to 30 cm.depth of soil profile. It is discernible from **Table 1** that the bulk density at 30-40 cm. depth was similar under both systems. There was no appreciable effect of no-tillage system on bulk density of soil below ploughing depth (below 30 cm) as compared to conventional tillage in wheat crop. Sharma *et al.*, (1984) found no significant differences in the bulk density under these systems.

Effect of tillage on soil moisture

The soil moisture was monitored at different crop growth periods, i.e., at the time of sowing, 85-days after sowing and harvesting stage of the crop as shown in **Table 2**. The average moisture content of 22.8% in no-tillage was slightly greater than in the conventional tillage (21.14%) up to 50 cm.depth of soil profile. This was because as sowing in no-tillage system was done 3 days earlier than in the conventional system. Soil moisture content was almost equal in both systems (20.34 and 20.38%, respectively,) after 85 days of sowing. But at harvesting stage higher moisture was observed in the conventional system (17.62%) than in the no-tillage system (17.08%). This may be due to greater depletion of soil moisture by the crop at harvest stage in the no-tillage system. Thus, more moisture is available to the plants at maturity stage in the no-tillage method. The higher moisture in lower depth under the conventional system indicated higher percolation losses from root zones. Sharma *et al.* (1984) observed high moisture retention, available moisture and moisture depletion during stress periods in no-tillage system.

Effect of tillage on shear strength of soil

Shear strength measurements taken after wheat sowing generally

Table 3. Shear Strength of Soil After Sowing Under Different Sowing Methods

Depth (cm.)	Shear strength (N/ sq. mm.)	
	No-tillage	Conventional tillage
0-5	1.23	0.24
5-10	2.15	0.50
10-15	2.48	0.98
15-20	2.50	1.84
20-25	2.52	2.29
Mean	2.17	1.17
S. D.	0.49	0.78

Table 4. Infiltration Rate at Sowing Time

Accumulated time (min)	Infiltration rate (cm/hr.)	
	No-till system	Conventional system
0	0	0
1	1.80	4.20
2	1.50	3.60
3	1.30	3.00
5	1.05	2.70
10	0.72	2.40
15	0.61	2.28
25	0.45	1.80
35	0.32	1.50
45	0.26	1.20
60	0.04	0.81
80	0.04	0.76

increased in depth as shown in **Table 3**. Higher values were obtained under the no-tillage system compared with the conventional tillage. Therefore, no-tillage probably offered more resistance to root growth than conventional tillage. It is clear from data that shear strength was high at 0-5 cm. depth in no-tillage (1.23 N/sq.) as compared to conventional tillage of 0.24 N/sq.mm. From a depth of 5 cm. onwards the difference in shear strength of soil under no-tillage and conventional system decreased with corresponding increase in depth of sowing up to 25 cm. Thus the values of shear strength for no-tillage system approached that of the conventional system near the depth of ploughing. Huges and Baker (1977) suggested that the wider use of zero-tillage techniques may result in more desirable soil structure being retained under intensive cropping situations.

Effect of tillage on infiltration rate

The rate of infiltration through the soil profile was rapid in the conventional system. Initially, it was 4.20 cm/hr. which decreased linearly and finally stabilized at the rate of 0.76 cm/hr. as shown in **Table 4**. In comparison, the initial infiltration rate in the no-tillage system was only 1.80 cm/hr. However, after 1 hour the infiltration rate was 0.04 and 0.76 cm/hr. in no-tillage and conventional tillage system, respectively. The high infiltration rate in the conventional system might be due to high soil porosity causing saturated flow down to the profile. Sharma *et al.* (1984) reported similar results in both no-tillage and conventional tillage systems.

Effect of tillage on crop parameters

The grain and straw yields of wheat under the no-tillage system were higher than that of the conventional system (**Table 5**). There was an increase of 17.09% grain yield of wheat under the no-tillage system which This might be due to greater availability of moisture at

Fig. 2 Measurement of germination count.

Table 5. Effect of Tillage Operation on Wheat Crop Production

Treatment	No-till seed cum fertilizer drill	Conventional tillage method	Increase decrease
Germination count (plant/ m.r.l.)	39.76	38.5	3.27
Effective tiller count (plant/ m.r.l.)	85.39	82.75	3.19
Weed count (plant/ sq. m.)	7.51	9.25	-18.81
Grain yield (q/ha.)	43.75	38.12	14.76
Straw yield (q./ha.)	70.06	61.49	13.93

Table 6. Effect of Sowing Methods on Energy Requirement and Cost of Operation

Item	No-till system	Conventional tillage system
Total time required to prepare and sow 1ha		
a. tractor hrs	2.19	9.21
b. human hrs	4.38	18.42
Rate of fuel consumption (li./hr.)		
a. tillage	0.00	4.10
b. sowing	3.20	3.20
Total fuel consumption (li./hr.)	7.01	35.79
Total energy equivalent (MJ*/ha.)		
a. human labour	8.58	36.10
b. fuel consumption	394.62	2015.33
Total energy required (MJ*/ ha.)	403.20	2051.43
Energy required (MJ*/q. of grain)	9.15	54.33
Cost of operation (Rs./ha.)		
a. tillage	0.00	1150.00
b. tillage and sowing	300.00	1450.00
Cost of operation (Rs./q. of grain)	6.81	38.54

*1 man- hr. = 1.96 MJ.
**1 litre diesel = 56.31 MJ.

Fig. 3 Wheat sown by no-till seed fertilizer drill at full bloom.

maturity stage, release of nitrogen by the decomposing stubbles, better germination and lower weed intensity under this system. Moreover by the advancement of 3 days in sowing, there may be advantage in yield, particularly under late sowing. The lower weed in no-tillage might be due to less disturbance of the soil. From **Table 4** the germination count (39.76 plant/m-run) and effective tiller count (85.39 plant/ m-run) were greater in the no-tillage system compared to that of the conventional system (38.50 and 82.75 plant/ m-run). Dhiman and Sharma (1986) reported 13.3% increase in grain yield by using zero-tillage (4.17 t/ha.) over broadcasting (3.68 t/ha.).

Energy and Economics

The energy requirements and cost of operations were higher in the conventional tillage system (2051.43 MJ/ha. and Rs. 1450/ ha.) than in the no-tillage system (403.2 MJ/ha. and RS. 300/ ha.) (**Table 6**). The energy required for both the no-tillage and conventional tillage systems were 9.15 and 54.53 MJ/q. of grain produced, respectively. The energy requirement and cost of operation per quintal of grain produced were 5.95 and 5.65 times more in the conventional tillage system than that of no-tillage system, respectively. Sharma et al. (1984) found that the no-tillage system required the least energy (0.56 kWh/ q. of grain) and reduced cost of production (RS. 2.89/ q. of grain)-about 1.5 times higher in conventional system (0.69 kWh/ q. of grain and RS. 4.23/ q. of grain)

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(*Continued from page 27*)

Slip-on-ring Spraying Devices for Spot Application of Chemicals to Control Eriophyid Mite in Coconut

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Slip-on-ring Spraying Devices for Spot Application of Chemicals to Control Eriophyid Mite in Coconut

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Abstract

Recently the coconut farmers were faced with harrowing times due to minute pest attack on coconut. The sudden outbreak of Eriophyid mite in coconut plantations has threatened the very survival of the copra industry in Southern India. To control the mite attack, spot application of pesticides is recommended as one of the remedial measures for which a slip on ring spraying device has been developed. The unit consists of a clamp, flexible hoses and nozzles. The unit is adjustable to suit any size of the coconut tree trunk. Flexible hoses with commercially available plastic (broad cone nozzles) nozzles are fixed to the delivery hoses surrounding the periphery of the clamp with the help of 'T' connectors. From the clamp all the flexible hoses are connected with main delivery line, which extends up to the bottom of the tree so that it can be attached with the commercially available rocker sprayer for spraying the chemical. Any number of flexible hoses with nozzle can be attached to the clamp. The cost of the unit for covering four to six bunches was Rs. 200 to 300 without the spraying unit. One set of clamp with required number of flexible hoses and nozzles, delievery pipe from the bottom of the tree have to be permanently fitted to each tree. Two persons are required to operate and move the sprayer unit in the coconut gardens. With rocker sprayer 20 to 25 trees can be sprayed per hour and with engine operated sprayer 25 to 30 trees can be sprayed in an hour. The discharge rate was measured at different pressure heads viz, 2.5, 5, 7.5 and 10 kg/cm^2 for different heights ranging from 3 to 15m by changing the nozzles from 1 to 4. The effect of spray height and operating pressure on the discharge of sprayer was investigated. The pressure coefficient is positive and significant indicating that if the pressure is increased by 1 kg/cm^2, the discharge is increased by 7.5 times at a given height for single nozzle, 15 times for two and four nozzles. The interaction coefficient between height and pressure is positive and significant indicating that increase in height increased the discharge by 0.15 times for one nozzle, decreased by 0.33 times for two, three and four nozzles. The height of spray has a negative correlation with discharge indicating that 1m increase in height reduced the discharge by 1.83 time at given operating pressure. The unit can be used for spraying 30 trees per hour. The slip-on-ring spraying device results in 80 and 75 per cent savings in cost and time when compared to conventional method of spraying.

Introduction

Coconut production in India has been increasing over the years. As a result, the country has emerged as the largest producer of coconuts in the world, though only third in area planted to the crop. Among the major coconut growing states, the share of Kerala in production was

42 per cent followed by Tamil Nadu with 31 per cent, Karnataka with 10 per cent and Andhra Pradesh with 8.8 per cent (Thampan, 1997). The present productivity level is the best in the world. Coconut products form a direct food source to a large section of people in the country.

Recently the coconut farmers were faced with harrowing times due to minute pest attack on coconut. The sudden outbreak of Eriophyid mite in coconut plantations has threatened the very survival of the copra industry in Southern India. The Eriophyid mite were present in the coconut groves throughout the year. But the peak populations were recorded during summer or dry periods. The mites attack 1 to 3 month old immatured nuts usually after pollination. By causing the immature button to fall, formation of abnormal buttons, poor development of butts, reduction in the nut size and kernel content and poor quality of husk associated with "gunmosis" discoloration and cracks, this mite has not only become a serious menace and but also has been inflicting heavy damage to coconut plantations in terms of yield reduction and economical return. To control the mite attack, spot application of pesticides is recommended as one of the remedial measures for which the following spraying device has been developed in the department of Farm machinery, College of Agricultural Engineering, TNAU, Coimbatore.

Fig. 1 Slip-on-ring spraying device.

Fig. 2 Slip-on-ring spraying device fitted in a coconut tree.

Table 1. Estimated Discharge at Various Levels of Height and Pressure for one Nozzle

Height of nozzle from ground level (m)	Discharge from one nozzle at different pressure heads (lit/hr)				
	2 kg/cm^2	4 kg/cm^2	6 kg/cm^2	8 kg/cm^2	10 kg/cm^2
3	51.14	67.15	83.17	99.19	115.21
6	40.57	57.52	74.47	91.42	108.37
9	30.01	47.89	65.77	83.65	101.53
12	19.45	38.26	57.07	75.87	94.68
15	8.89	28.63	48.37	68.11	87.84
18	0	19.00	39.67	60.33	81.00
21	0	9.37	30.96	52.56	74.16

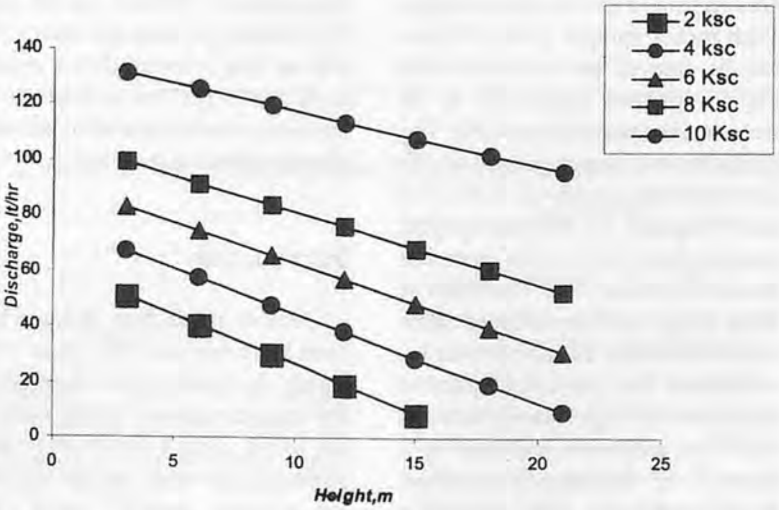

Fig.3. Estimated discharge at various levels of heighty and pressure for one nozzle.

Review of Literature

Occurrence of Mite

The first report of this Eriophyid mite in coconut was made in 1960 in the state of Guerrero in Mexico. Later its occurrence was reported from several states in Africa and Central and South America. It is a notorious pest in the coconut groves in the Caribbean islands, Africa and America where it causes an estimated loss up to 25 % in yield of copra. In India, report on the infestation of this mite in coconut palm was also available.

A survey undertaken recently by the ICAR team from Delhi in Tamil Nadu revealed that the infestation was severe (> 40 %) in Coimbatore, Erode, Thanjavur and Theni districts. It was medium (10-40 %) in Madurai district and mild (0-10 %) in Cuddalore and Pudukkotai and other districts.

Control of Mite

Chemicals like dicrotophos, monocrotophos sprayed into bunches of developing fruits every 20 or 30 days significantly reduced the damage. For spraying the liquid pesticidal molecule in coconut palm, manually operated mist blowers and hydraulic sprayers and power operated hydraulic sprayers can be used.

Hand-operated Sprayers

The Micron sprayers Ltd., Three mills, Bromyard, U.K developed a hand-held sprayer which is ideal for spot–on application of pesticides without risk of drift. This hand-held and back-mounted system is avail-

Table 2. Estimated Discharge at Various Levels of Height and Pressure for Two Nozzles

Height of nozzle from ground level (m)	Discharge from two nozzles at different pressure heads (lit/hr)				
	2 kg/cm^2	4 kg/cm^2	6 kg/cm^2	8 kg/cm^2	10 kg/cm^2
3	59.50	87.98	116.47	144.95	173.44
6	52.49	78.99	105.49	132	158.5
9	45.48	70	94.53	119	143.57
12	38.47	61.01	83.553	106.09	128.63
15	31.46	52.02	72.58	93.14	113.69
18	24.45	43.03	61.60	80.18	98.76
21	17.43	34.03	50.63	67.23	83.82

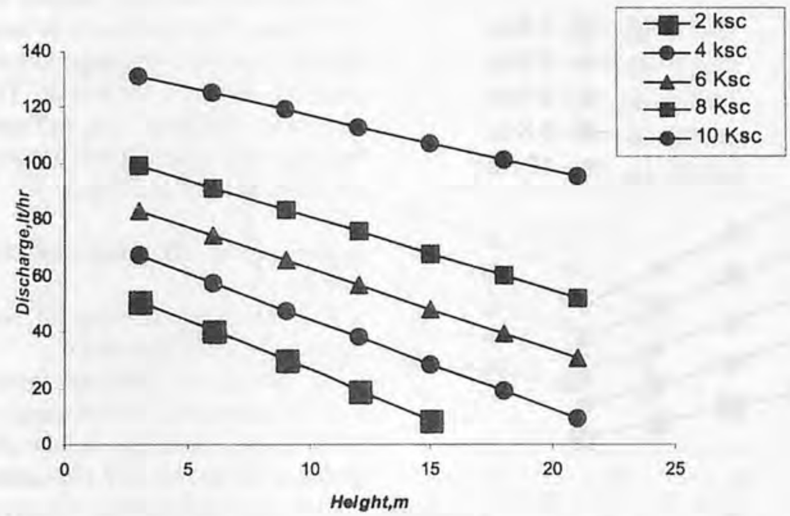

Fig.4 Estimated discharge at various levels of height and pressure for two nozzles.

able as the Accudos 25 which allows the operator to dispense and deliver a measured volume of spray liquid to a closely targeted and small area thus providing the high levels of accuracy, spatially and in dosage.

Materials and Methods

Slip-on-Ring Spraying Device

To control the mite attack, spot application of chemicals is recommended as one of the remedial measures for which slip-on ring spraying device was developed at the Department of Farm Machinery. The unit can be easily clamped and fitted to the top of the tree trunk. The unit consists of three parts, viz., clamp, flexible hoses and nozzles.

The clamp is made of mild steel flat and can be fitted at the top portion, just below the crown of the tree with the help of a ratchet type locking arrangement (**Fig.1**). It is adjustable to suit any size of the coconut trees. Flexible hoses with commercially available plastic (broad cone nozzles) nozzles are fixed to the delivery hoses surrounding the periphery of the clamp with the help of 'T' connectors and the position of the nozzles can be adjusted to suit the bunch position. Because of flexibility of line hoses, the nozzles can be fixed directly on the top of bunches (**Fig.2**) using the iron hooks provided at the end of the flexible hoses. From the clamp all the flexible hoses are connected with main delivery line, which extends up to the bottom of the tree so that it can be attached with the commercially available rocker sprayer for spraying the chemical. Any number of flexible hoses with nozzle can be attached to the clamp.

Evaluation of Slip-on-Ring Spraying Device

The device was fitted to the coconut tree and the spraying performance was evaluated. The discharge rate was measured at different pressure heads viz, 2.5, 5, 7.5 and 10 kg/cm^2 by collecting the liquid from the nozzle. At each pressure setting, the test was replicated thrice and the mean value was recorded. The spray was collected for a time period using stopwatch into a measuring cylinder. The measuring period should be at least 60 seconds and for convenience it is limited to 30 seconds. The test was repeated for different heights ranging from 3 to 15m by changing the nozzles from 1 to 4.

Results and Discussion

The results of the experiments conducted to study the performance of existing and developed models for spot application of chemicals are discussed below.

Performance Characteristics of Slip-on-Ring Spraying Device

The existing model of sprayer was tested for performance. Various functional forms were tried to study the effect of spray height and operating pressure on the discharge of sprayer. Based on the R^2 value and the predicting ability of the functional forms, a suitable function was selected. The suitable function is of the form,

$$Q = \beta_0 + \beta_1 H + \beta_2 P + \beta_3 H P$$

Where

Q = Discharge, lt/hr

H = Height from the ground, m

P = Operating pressure, Kg/cm^2

β_0, β_1, β_2 & β_3 = Functional coefficients

For different number of nozzles, different functions were estimated by the method of OLS (Ordinary least square method).

a.Discharging efficiency for one nozzle

The estimated function for one nozzle is given **Equation a**.

Here the R^2 value is very high and

Table 3. Estimated Discharge at Various Levels of Heighyt and Pressure for 3 Nozzles

Height of nozzle from ground level (m)	Discharge from three nozzles at different pressure heads (lit/hr)				
	2 kg/cm^2	4 kg/cm^2	6 kg/cm^2	8 kg/cm^2	10 kg/cm^2
3	81.4	114.85	148.29	181.73	215.17
6	73.26	104.07	134.89	165.69	196.51
9	65.12	93.3	121.48	149.66	177.84
12	56.98	85.53	108.07	133.63	159.17
15	48.83	71.75	94.67	117.59	140.51
18	40.69	60.98	81.27	101.55	121.84
21	32.55	50.21	67.86	85.52	103.18

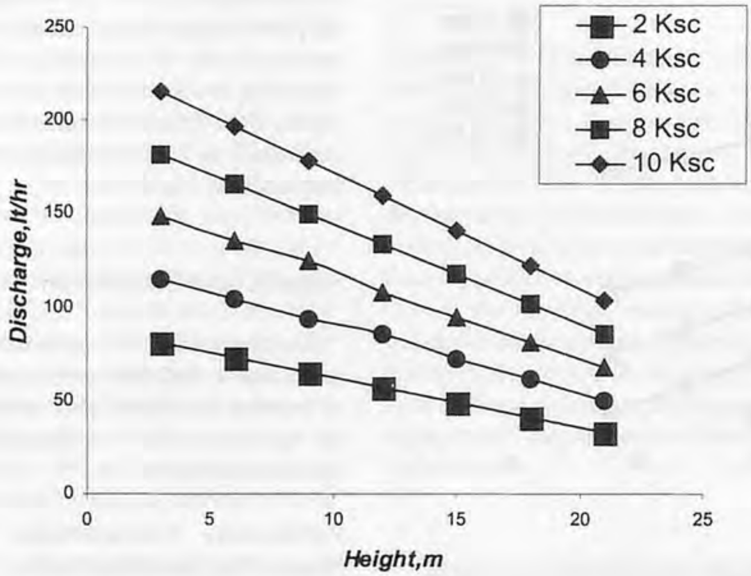

Fig.5.Estimated discharge at various levels of height and pressure for three nozzles.

significant, indicating that the discharge is 97.81 % accounted by height and pressure. Moreover, the chi-square value for the above function is not significant at 5 % level indicating its goodness. The figure in parenthesis shows the T value indicating that the parameters, operating pressure and height have a significant effect on discharge.

The sign of the height coefficient is negative and significant indication that in the case of one nozzle, if height increases, the discharge will decrease significantly at a given pressure level. The pressure coefficient is positive and significant indicating that if the pressure is increased by 1kg/cm^2, the discharge will be increased by 7.5 times at a given height. The interaction coefficient between height and pressure is positive and significant indicating that as the height increases, the discharge will also increase by 0.15 times. This may due to the negligible reduction in discharge with increasing height for the nozzle. The estimated discharge for different heights and pressure heads are presented in **Table 1** and **Fig. 3**.

b.Discharging efficiency for two nozzles

The estimated function for two nozzles is given **Equation b**.

R^2 value is very high and significant indicating that the discharge is 97.88 % accounted by height and pressure. Moreover, the chi-square value is not significant at 5 % level and T value shown in parenthesis significant at 5% level indicates the goodness of the result. From the model, the operating pressure has a positive correlation with discharge indicating that if the pressure is increased by 1kg/cm^2,the discharge will be increased by 15 times at a given height.

The sign of the height coefficient is negative and significant indicating that the discharge will decrease significantly at a given pressure level. The interaction coefficient between height and pressure is negative and significant indicating that as the height increases, the discharge will be decreased by 0.33 time. The estimated discharge for different heights and pressure heads are presented in **Table 2** and **Fig.4**.

c.Discharging efficiency for three nozzles

The regression model for three nozzles is given **Equation c**.

Here the R^2 value is very high and significant showing that discharge is 99% accounted for by height and op-

$$\hat{Q} = 46.6085 - 3.830095\hat{H} + 7.544541\hat{P} + 0.154947HP \quad (R^2=0.9781)$$
$$(-9.660069) \quad (14.003180) \quad (2.675620)$$

Equation a

$$\hat{Q} = 36.0574 - 1.677218\hat{H} + 15.231315\hat{P} - 0.330091\,HP \quad (R^2=0.9788)$$
$$(-3.059718) \quad (20.448082) \quad (-4.122837)$$

Equation b

$$\hat{Q} = 53.4790 - 1.837482\hat{H} + 18.036069\hat{P} - 0.438458\,HP \quad (R^2=0.9902)$$
$$(-4.243750) \quad (30.654319) \quad (-6.933062)$$

Equation c

$$\hat{Q} = 56.6167 - 1.244804\hat{H} + 22.713737\hat{P} - 0.645748\hat{H}\hat{P} \quad (R^2=0.9742)$$
$$(-1.462949) \quad (19.644459) \quad (-5.195918)$$

Equation d

Table 4. Estimated discharge at various levels of height and pressure for four nozzles

Height of nozzle from ground level (m)	Discharge from four nozzles at different pressure heads (lit/hr)				
	2 kg/cm²	4 kg/cm²	6 kg/cm²	8 kg/cm²	10 kg/cm²
3	94.43	135.98	177.54	219.09	260.65
6	88.83	124.5	162.18	199.86	237.54
9	79.22	113.02	146.83	180.63	214.43
12	71.61	101.54	131.47	161.39	191.32
15	63.99	90.05	116.11	142.16	168.22
18	56.39	78.57	100.75	122.93	145.11
21	48.78	67.08	85.39	103.7	122.00

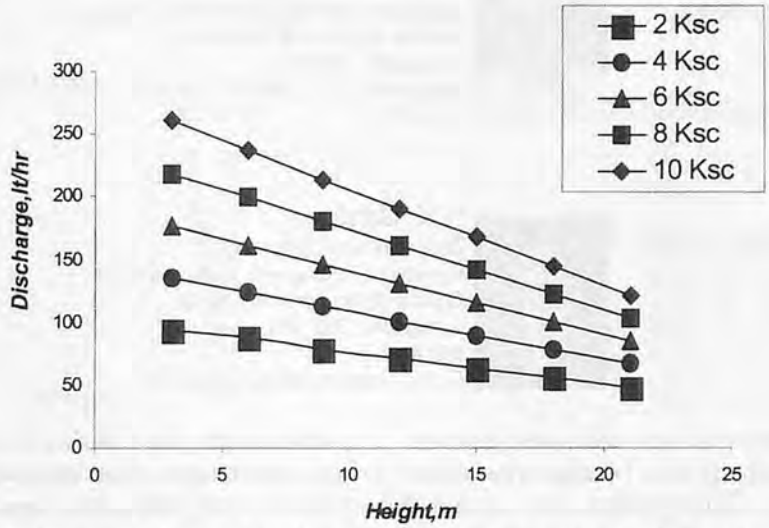

Fig.6. Estimated discharge at various levels of height and pressure for four nozzles.

erating pressure. Moreover, the chi-square value for the above function is not significant to indicate its goodness. The values shown in parenthesis indicate that the pressure and spray height have a significant effect on discharge at 5% level. The height of spray has a negative correlation with discharge indicating that as the height increased by 1 m, the discharge will be reduced by 1.83 times at a given operating pressure. The pressure coefficient is positive and significant indicating that if the pressure increases, the discharge will increase significantly at a given height. The interaction coefficient between height and pressure is positive and significant similar to the case of two nozzles. The estimated discharge for different heights and pressure heads are presented in **Table 3** and **Fig.5**.

d.Discharging efficiency for four nozzles

The estimated function for four nozzles is given **Equation d**.

Here also the R^2 value is very high and significant (R^2=0.9781). It indicates that the discharge is 97.81% accounted for by the height and pressure. Besides, the value of chi-square is not significant at 5% level and the T value (shown in parenthesis) is significant at 5% level supporting the result.

The sign of the height coefficient is negative and significant indicating that in the case of four nozzles, if the height is increased by one unit, the discharge is decreased by 1.24 times at a given operating pressure. Similarly, the pressure coefficient is positive and significant indicating that if the pressure is increased by 1kg/cm², the discharge will be increased by 22.7 times at a given height. The interaction coefficient has a similar effect on the discharge as in the case of two and three nozzles. The estimated discharge at various levels of height and pressure for four nozzles are shown in **Table 4** and **Fig.6**.

Cost of spraying

Number of tress sprayed per hour with slip-on-ring device, 30;

Number of trees sprayed per hour in manual spraying, 8; and

Savings in time by using slip-on-ring device, 73%.

Total cost of operation of slip-on-ring spraying device, 33Rs/hr;

Cost of operation per tree, 1.00Rs/tree;

Cost of operation for manual spraying, 12.50Rs/hr;

Cost of manual spraying, 5.00Rs/tree;

Saving in cost with slip-on-ring spraying device when

compared with manual spraying, 80%.

Conclusions

From the laboratory trials, it was concluded that the pressure coefficient is positive and significant indicating that if the pressure is increased by 1 kg/cm², the discharge will be increased by 7.5 times at a given height for single nozzle, 15.2, 18.0 and 22.7 times at a given height for two nozzles, three nozzles and four, respectively. The interaction coefficient between height and pressure is positive and significant indicating that as the height increases, the discharge will also be increased by 0.15 times for one nozzle. For all the nozzles tested, the height of spray has a negative correlation with discharge indicating that as the height increased the discharge will be reduced at given operating pressure. On the other hand, the pressure coefficient is positive and significant indicating that if the pressure increases, the discharge will increase significantly at a given height. The slip-on-ring spraying device results in 80 and 75 per cent savings in cost and time when compared to the conventional method of spraying.

(Continued on page 22)

Development and Testing of a Tractor-mounted Positioner for Mango Harvesting

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Abstract

In order to reduce losses sustained during harvesting of mango and to maintain fruit quality, a tractor-mounted positioner was developed and tested for mango harvesting at the Sagadividi farm of the Gujarat Agricultural University, Junagadh Campus. During operation, it was observed that using the positioner for harvesting, only the mature fruits with stalk of 10-20 mm length without sap burns and any other damage to the fruits, could be harvested. White layer (bloom), which is desirable from quality point of view, was also maintained. Though the work output was slightly reduced over all economics was in favour of the use of the positioner for harvesting as compared to the traditional picker. Using a positioner in orchards can save about Rs. 1,000 per tree in a good season.

Introduction

Mango (Mangifera indica), the "king" of fruits, has prime importance among the commercial fruits grown in India-the largest producer and exporter of mango in the world. In Gujarat about 382 thousand tonnes of mango is produced annually over an area of 57 thousand hectare (Data book 2000). Gujarat produces export quality of mango mainly the Alphonso and Kesar varieties. The latter has excellent quality for export and grown almost throughout the state, concentrating in South Gujarat and Saurashtra. The quality of the fruits mainly depends on their maturity stages , harvest and post harvest techniques adopted by the mango growers.

Harvesting of fruits in India is mostly done manually by means of a curved knife, pair of scissors or blades attached to a hanging basket to the distal end of bamboo sticks (Devnani, 1980). For harvesting mango, hand picking manually operated low capacity gadgets and tree shaking methods prevaile which results in high labour and energy requirements, drudgery, damaged fruits, damage to tree branches etc. The damage and bruising are very serious problem. The fruits should not be allowed to fall on the ground as the injured fruits cause spoilage to other healthy fruits during packaging and storage. Fruits harvested with 8-10 mm long stalks appear better on ripening as undesired spots on the skin caused by sap burn are prevented. Such fruits are less prone to stem – end and rot and other storage diseases (Sapovadia et. al. 2001).

RTTC, Jurhat, Assam (1988) worked on fruit harvesting devices. The manually operated unit worked on the principle of individual fruit cutting by sickle / blade and collecting the fruit in a bag. The unit was found suitable for average size and big fruits, which would be damaged if allowed to fall freely on the ground. The other unit worked on the principle of mechanical shaking of tree. This unit was suitable for hard fruits. Brown and Schertz (1967) also worked on mechanically operated harvesters and reported that fruits harvested by mechanical shaking have more injuries in the form of splits, internal and external bruising and superficial peel scars than manually harvested fruits.

RTTC, Gujarat Agricultural University, developed an improved

Table 1. Anthropometrical Observations of the Operator

Age, Years	Sex	Height, cm	Weight, kg	Palm size, cm	
				Length	Width
21	M	171.00	62.00	21.00	9.00
20	M	188.00	60.00	20.50	8.00
18	M	155.00	58.00	19.00	7.50
23	M	159.00	62.00	20.00	8.00
21	M	172.00	64.00	20.00	7.00
19	M	175.00	65.00	21.00	8.00
26	M	173.00	70.00	19.50	8.00
28	M	170.00	61.00	21.00	9.50
24	M	165.00	56.00	18.00	8.50
21	M	180.00	70.00	21.50	9.00
Average		170.00	62.80	20.20	8.30

Table 2. Characteristics of Mango Trees (Kesar Variety)

	Height, m	Canopy, radius, m	Distance between trees, m
	7.0	7.0	11.0
	6.0	10.0	10.0
	8.0	8.0	11.0
	10.0	12.0	11.0
	7.0	7.0	11.0
	8.5	8.5	12.0
	6.5	10.0	12.0
	9.0	7.5	10.0
	11.0	7.0	12.0
	7.5	10.0	11.0
Average	8.5	8.7	11.1

Table 3. Mango Fruit Distribution within the Tree (Kesar variety)

	Outside, %	Inside, %	Top, %
	50	20	30
	57	20	23
	59	18	23
	70	12	17
	58	17	25
	58	20	22
	62	18	20
	60	15	25
	71	12	17
	64	16	20
Average	60.5	16	22

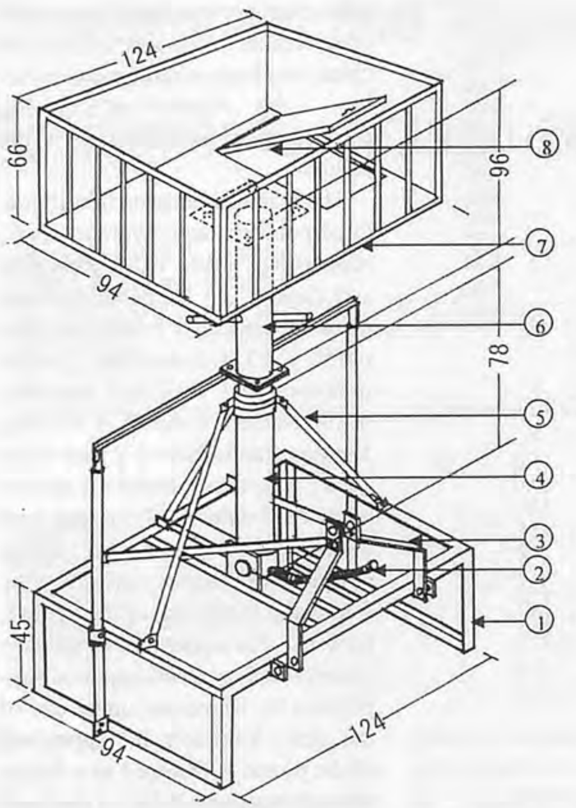
picker and it showed better performance as compared to other pickers collected from various centres of the country. About 90% of the fruits could be harvested with stalk of 10-20 mm in length, which is most desirable specifically for export quality of fruit. Fruits should be harvested manually using mechanical aids like a positioner on which a person can stand and pick the fruit using a pair of scissors / secateure. As the fruits are picked form very close distance hence, only mature fruits are harvested without any damage. Hence, keeping the foregoings in view, a study for developing and testing of a tractor-driven and hydraulically operated positioner was undertaken at the centre.

Material and Methods

Prior to the design of the machine some preliminary information regarding the tree characteristics were studied to ensure that the movability of the machine in the field, distribution of fruits within the tree and the percentage of fruits that can be harvested are estimated (Tables 1 to 3). The height of the machine and size of the cage were likewise studied. Using the above information a hydraulically-operated positioner for harvesting mango and other fruits, was designed and developed. The safety factors were also taken into consideration. The cost of the machine was kept minimum by reducing the number of moving components in the design of the machine.

The machine consists of a frame, three-point linkage, hydraulic jack, supporting links, extension pipe and cage. The frame of the machine is fabricated from angle iron of (50 × 50 × 6) mm size. The dimensions and structural members of the frame are shown in the **Fig. 1**. A hydraulic jack of 2 tonnes capacity with two cylinders is mounted at the centre of the frame with the help of a pin of 40 mm passing through two plates welded to the frame and lower end of the hydraulic jack. The upper end of the jack is supported by fastening three supports to the frame and upper end of the jack. Similarly, the upper end of the piston is fastened to a flange through nuts and bolts. To extend the height of the positioner an extension pipe of 100 mm and 1 m length is attached to the upper end of the piston through flange, nuts and bolts. On the upper end of the extension pipe another flange of the same size (20 × 20) cm is welded on which cage is fixed through nuts and bolts. The cage of machine is fabricated from angle iron, mild steel flat and wood. The frame of the cage is made out of angle iron. The size of the cage is (92 × 76 × 70) cm. At the bottom of the cage, wooden plank is provided. On one side of the bottom an opening of (55 × 47) cm size is provided through which an operator can get on the positioner to pick up the mature fruits. All the four sides of the positioner are kept folding so that when the machine is on transport from one place to another the sides can be lowered to keep the height minimum.

To operate the machine, it is hitched to a tractor through three point linkages and hosepipe of the hydraulic jack is connected to the



SR. NO.	COMPONENT	NT
8.	OPENING	
7.	CAGE	
6.	EXTENSION PIECE	
5.	JACK SUPPORT	RT
4.	HYDRAULIC JACK	
3.	3-POINT LINKAGE	
2.	HOSE PIPE	
1.	FRAME	

Fig. 1 Tractor-mounted positioner for harvesting mango.

Fig. 2 Positioner attached with power source.

Fig. 3 Operator picking mango using positioner.

hydraulic system of the tractor. The cage is mounted on top of the extension piece and its sides are folded. The machine is transported to the orchard where mango picking is to be done. During operation, the machine is placed on ground and operator gets on the cage along with a pair of scissor and carton through the opening provided at the bottom of the cage. All the sides of the cage are kept in upright position and hinged to the frame through hooks pins for safety point of view. The hydraulic system of the tractor is operated to lift the cage. As soon as the valve is opened, the oil under pressure goes to jack through hosepipe, which lifts the piston of the jack, thus, the cage is lifted. When required height is reached, valve is closed to stop further upward movement of the cage. Then, the operator pick the fruits from a very close distance using a pair of scissors / secateure. Only matured fruits are picked and kept in the carton. When the carton is full of fruits it is packed and taken on the ground. The machine is taken around the tree to pickup matured fruits. Some of the fruits which are located on the top of the tree, are beyond the reach of the operator, are picked using manually operated mango picker.

Testing

A field testing of the machine was conducted at the Sagdividi farm of Gujarat Agricultural University, Junagadh campus for the Kesar variety of mango which is very popular among in the Saurashtra region of Gujarat state. The trees were planted at (12 × 12) m distance. HMT zetor tractor of 35 hp was used to operate the machine. An experienced worker was engaged to pick the fruits in standing posture on the positioner. During testing of the machine some important observations like number of fruits harvested / h, weight of fruit harvested / h, average stem length (mm), visible damage (%), physiological loss of weight (%), shelf life of fruits (days) etc. were recorded.

The cost of harvesting was determined out considering the prevailing rates of the tractor and labour during the season. Two workers, one for picking the fruits and another to receive the harvested fruits, were required for the operation. The experienced worker is engaged in picking the fruits and was paid better than the less experienced worker. The same workers were

Table 4. Comparative Test Results of Fruits Harvested, by Method

Item	Harvesting methods	
	Manually using positioner	Manually using traditional picker
Principle of harvesting	Shearing	Impact
Harvesting capacity		
Average number of fruits harvested (No/h)	360.00	377.00
Average weight of harvested fruits (kg / h)	62.87	68.00
Average stem length (mm)	20.9 (Uniform)	50.3 (Non – uniform)
Visible damage (%)	Nil	11.11
Average shelf life of fruits (days)	9.00	6.00
Cost of operation		
Man – hours used (No. / tonne)	15.90	14.70
Tractor – hours used (No. / tonne)	15.90	-
Cost of harvesting (Rs. / tonne)	2783*	368

Hiring charges for tractor along with machine and driver Rs. 150 / h.
Labour charges Rs. 200 / day.
* Labour + tractor charge (Rs 398 + 2385) = 2783.

Fig. 4 Fruit packet being taken from the positioner.

Fig. 5 Operator picking coconut using positioner.

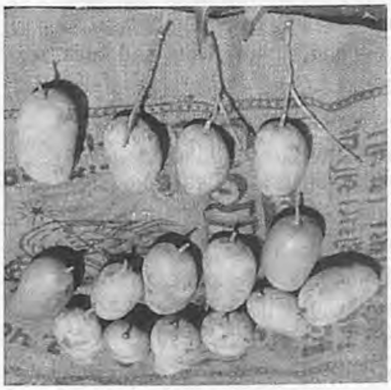


Fig. 6 Fruits harvested using traditional mango picker.

Fig. 7 Fruits harvested using developed positioner.

used to harvest the fruits using the developed machine.

In order to estimate physiological loss in weight (PLW) of the harvested fruits two plastic trays lined with newspapers, were kept on the table at room temperature (20°) and the harvested fruits were arranged in these trays in line keeping the stem end upward. The weight of the fruits was recorded every three days. On the 7th day, few fruits harvested using traditional picker showed symptoms of deterioration , are removed from the tray.

Results and Discussion

(i) Harvesting capacity

The results recorded during the trial of the machine are shown in Table 4. The average number of fruits harvested using the positioner were 360 per hour compared with local mango picker which can pick an average of 377 fruits per hour. Thus, using the positioner the harvesting capacity of the operator was slightly reduced. Considering that in raising / lowering and shifting the positioner took more time. Similar results were reported by Schertz (1967). During his study he observed that an operator standing on the ground was more efficient than harvesting the fruits from a ladder / positioner.

(ii) Stem length

The stem length is one of the most desirable parameter', The stem length of the stem fruits harvested using the positioner was within 20 mm. and uniform while in fruits harvested with traditional picker, had stems more than 50 mm and non-uniform. A number of fruits were harvested without stem, which is not desirable from the quality point of view. Such fruits do not have good appearance and a mango grower has to sell them at lower prices in the market. Moreover, it has been reported that fruits harvested without stem are subject to the occurrence of stem end rot disease. Fruits with stems recorded delayed ripening. It is necessary that the fruits should have stems ranging from 10 to 20 mm.

Table 5. Effect of Method of Harvesting on Physiological Loss in Weight Of Fruits

Storage period (Days)	PLW(%)	
	Manually harvesting using positioner	Manually harvesting using traditional picker
0.00	-	-
3.00	2.92	3.53
6.00	8.87	11.11
9.00	13.29	15.88

Fig. 8 Tractor mounted positioner.

(iii) Visible damage

Visible damage on the fruit was observed in the form of sap burns. The fruits harvested without stem had sap burns. Such type of damage was almost nil in fruits harvested using the positioner because all the fruits had stem while the fruits picked using the traditional picker shows 11.11% visible damage.

(iv) Shelf life of fruits

This refers to the life of fruits in days for which they can be stored after harvesting without sustaining spoilage. The shelf life is affected by the harvesting methods. Fruits harvested using the positioner could be stored for 9 days without showing symptoms of spoilage. The appearance of the fruits was good and had attractive color. In comparison, those harvested using the traditional picker should dark spots on the body on the 7th day from the date of harvesting. If the fruit is physically damaged or injured the respiration rate of the fruit is increased and it is prone to microbial attack hence, during handling of the mango fruit, care taken to avoid any kind of injury and increase the shelf life of the fruits.

(v) Cost of harvesting

As indicated in the Table 4 the cost of harvesting for using the positioner was Rs. 2783 / tonne of mango fruit as compared to Rs. 368 / tonne using the traditional picker. Thus, the cost of operation for the former was high but the quality of harvested fruit was very good and not a single fruit was lost by way of spoilage or decay while 10 –15% fruit loss was observed in case of traditional picker. Hence, considering 10% loss out of every 1000 kg. only 900 kg. of fruits were available for sale. That too at lower rate (Rs. 17.50 / kg.) amounting Rs. 15,750. The fruit harvested using the positioner could be sold at higher price (Rs. 20 / kg.) amounting Rs. 20,000, thus gaining Rs. 4,250 more as compared to using the local picker. Subtracting the extra operating cost required in the case of the positioner i.e., Rs. 2,415 a net profit of Rs. 1835 / tonne could be harvested by a mango grower. In other words, about Rs. 900 / tree can be saved by adopting the developed positioner for harvesting of mango.

(vi) Physiological loss in weight

Observations regarding the physiological loss in weight (PLW) were also recorded every three days in the laboratory for each method of fruit harvesting in percentage and presented in Table 5. The PLW was higher on 3rd, 6th and 9th day for the fruits picked using the traditional mango picker. The total PLW was 13.27% and 15.88% for fruit harvested with the positioner and traditional picker, respectively.

Conclusions

From the study following conclusions can be drawn:

Using the positioner, mangoes without any mechanical injury are picked and only matured fruits are harvested as operation is conducted at a close distance.

As 100 percent fruits are harvested with stems (1-2 cm), no sap burns were found and white layer (bloom) on the fruit is also maintained.

Loss of fruit during storage and transportation is minimized.

Due to high quality of fruit maintained during harvesting an fruit grower can harvest a net sum of Rs. 1000 per tree in a good season.

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Manual Sugarcane Harvesting System vs. Mechanical Harvesting System in Thailand

by

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Abstract

Two types of sugarcane harvesting system in Thailand, manual harvesting systems and mechanical harvesting systems, are compared. The low productive manual harvesting system is still popular which will continue in the near future due to its low cost. The existing mechanical harvesting system does not suit Thai farming practice as the expected high field efficiency cannot be reached. Small-to medium-sized harvesting machine is most suitable one for Thai cane fields. Technical problems in chopper harvesting are analysed.

The Manual Harvesting System

Sugarcane harvesting season in Thailand begins at the end of September and lasts till March of the following year. In these three-to four-month periods, rural labor—mainly from north-eastern region of Thailand—rush in and tempo rarily settle in sugarcane plantations scattered in the central basin region. The labor force, together with loading and conveying vehicles, constitute the component of powerful manual harvesting system, which delivers 335.610 tons of raw cane material to the 46 mill plants each day.

The manual harvesting systems, varying from cutting and loading practice, can be divided into four types. In the first type, labor cuts green cane, removes cane leaves and tops, piles it in 10 to 20 canes per pile and bundles it up. The bundle is then lifted onto trucks manually. Cane growers pay the labor either based on the finished cane tonnage or on the finished field area. The second type of harvesting sees the canes are cut, de-trashed and topped manually. Four rows of the cut cane are laid down in a single row sans bundling. A grab loader collects the cut cane and loads it in truck. Cane cutters are normally paid on their finished field area.

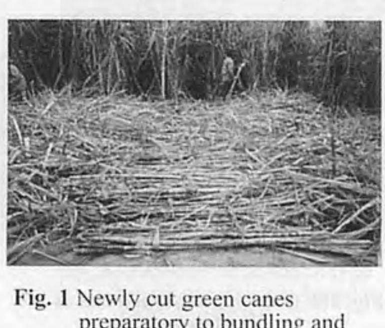

Fig. 1 Newly cut green canes preparatory to bundling and loading.

Fig. 2 The canes are cut and arranged in rows for mechanical loading without bundling.

Table 1. Labor Productivity for Manual Harvesting System

Harvesting method	first type	second type	third type	fourth type
Composition in harvested cane	<1%	38%	61%	(Insignificant)
Capacity (kg/person-day)	2,906	4,685	5,538	
Income per labor (Baht/ton)	109.7	182.4	195.6	
Harvesting cost (Baht/ton)	45.7	47	42.9	
Workers' attitude	not like	less like	most like for easy cut & high pay	

Table 2. Comparative Performance of Number of Loading Workers

Number of workers	Time used (hour)	Cane loaded (ton)	Capacity (ton/person-hour)
6	6.2	26.8	0.72
7	5.3	25.9	0.69
8	4.7	27.1	0.72
10	4.3	26.3	0.61

Table 3. A Comparison of the Four Loaders'capacities

Type	Front type	Rear type	Side type	Tri-wheeled type
Fuel consumption (liter/tonnage cane)	0.5	0.46	0.42	0.45
Time for noe truck load (h)	2.27	1.49	1.25	1.36
Loading capacity (truck/day)	2.6	3.4	3.6	3.6
Loading capacity (ton/day)	44.98	60.11	62.64	64.44
Latent capacity (ton/day)	80.17	135.8	162.4	169.2
Seasonal capacity (ton)	4,408	5,891	6,139	6,315
Loading cost (Baht/ton)	19.1	22.4	17	29.6
Total cost (Baht/year *)	83,973	153,985	104,542	186,675
Income (Baht/year)	121,221	176,723	184,162	189,454
Profit (baht/yuear)	37,248	22,739	79,619	2,779

*yearly total fixed cost and running costs.

Fig. 3 Seven workers were found loading a truck in cane field.

Fig. 4-A Comparative structures of lane loaders in use.

For the third type, the workers cut the cane, top it sans bundling and load it directly in trucks manually. Payment is carried out on the finished cane tonnage basis.

The fourth type, now seldom practiced since the 1996, relies on government regulation concerning environment issue, in that workers burn the cane in field condition, cut it and load it either manually or mechanically. (This type time coincides with Thai's dry season. Burning the cane field is the most effective means of-trashing, the canes. The fire leaves behind only the clean cane stalks, making it easy for manual or mechanical harvesting.)

Manual loading of cane needs at least 5 workers. Normally, two workers hand in the cut stalks to the one standing on the side of the truck on a tyre-high position who lifts the canes to fourth worker in the truck bin in laying the canes properly. The last worker with a long-handled knife in hand cuts irregular canes for dense material load. On some occasions, the number of workers. The third worker involved can reach 10 for a single truckload.

Manual loading of cane is the most tiring work with low efficiency. The conveying vehicle also wastes a lot of time in waiting for the load. Thereby mechanical loading is both welcomed by truck drivers and field workers. In the past few years, the applied units of mechanical loader have steadily increased.

Four types of loaders are found in use. The front-mounted tractor A is a push-pile loader. The rear-mounted tractor B is the push-pile loader. The side-mounted tractor C is a grab-loader. The self-propelled tractor D is another grab-loader on 3 wheels only.

High loading capacity of loaders requires high cutting speed. Such

Fig. 4-B Comparative structures of lane loaders in use.

Fig. 4-C Comparative structures of lane loaders in use.

Fig. 4-D Comparative structures of lane loaders in use.

Fig. 5 A modern chopper harvester on field trial.

Fig. 5 A modern chopper harvester on field trial.

Fig. 6 A specially modified model of chopper harvester for the Thai sugar industry, TS2001, in action.

requirement conflicts with Thai farming practice. Owing to the small-to medium-sized field layout and the need for direct supervision in field course, cane growers seldom hire a big labor team for work. Such situation naturally results in mechanical loaders' low overall field efficiency. A field loader should wait for truck presence, for cut cane, for labor adjustment or other minor delays. As machine service is commonly carried out on hire-rent basis between mill plant and cane growers, mechanical service fee should not exceed manual service cost from growers' perspective. Such restriction thereby precludes high machine service charge. And consequently, the poor economic performance discourages the usage of mechanical loader to a large extent.

Mechanical Harvesting System

The only two mechanical harvesting systems in actual use in Thailand are both chopper-harvester type. One is composed of a chopper harvester (American or Australian made) and the accompanying transportation tracks. The other is made of a medium-sized chopper harvester (TS2001, a specially modified Australian model for the Thai sugar industry), that comes with a mobile lifter and in-field tracks. Other systems, having been developed or are developing in recent years, include the Marell type cane harvester and two mini-sized cane harvesters. They were developed in CSRDC (Cane and Sugar Research and Development Center) at Kasetsart University and A.I.T (Asian Institute of Technology), respectively. The objective of these activities was to develop simple harvesting machines which can serve as an alternative to the sophisticated and expensive chopper harvesters. The imported large machines do not strictly suit Thai farming requirements. The typical characteristic of Asian farming practice with field length can seldom reach 200 to 300 meters long. The patch field greatly exhausts chopper harvester's field operation, resulting into terribly low field efficiency. Investigation on one model of chopper harvester showed that valid time utilization ratio can only reach 42%. Many years' effort, both from government and technical staff, has failed to change cane growers' farming practice. Shifting patch field into large area is impractical both from farmers' view and from technical points of view such as irrigation or field management. Therefore, the small-to medium-sized harvesters seem to stay in the country.

Unfortunately, none of the above-mentioned efforts has reached the success stage. The Marell type machine once showed its potential in burned cane field. Yet the 1996 farming regulation completely changed its fate. When used in green cane field, it faced with some fatal problems, which include total inability of de-trashing, severe transporting trouble and inadequate power output. The mini-walk-type cane harvesters also showed power shortage. Their crop

Fig. 7 A special purpose lifter is used to lift and load, which is bag dumped from TS2001.

Fig. 8 Overview of a Marell type cane harvester developed in 1997 in CSRDC

Fig.9 When used in harvesting of green cane, de-trashing is the biggest headache left by the Marell harvester.

Fig. 10-A A walk-type mini-harvester developed in A.I.T in 1992.

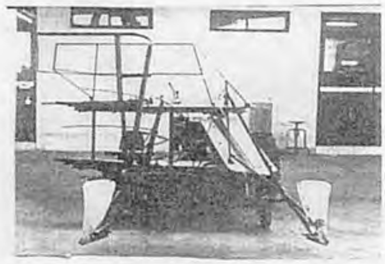

Fig. 10-B A walk-type mini-harvester developed in A.I.T in 1992.

Fig. 11 A walk-type mini-harvester developed in CSRDC in 1994.

guidance and stalk handling ability was unsatisfactory, especially in heavy crop conditions or in heavy lodged field.

Comparison and Result

There are totally 250 units of chopper harvesters in use in Thailand at present, mostly working in the relative large area cane fields. The Mechanical harvesting system only contributed a limited part of capacity in cane harvesting operation. The main hindrance for machine application is the poor economic performance. Other negative effects in machine use include trash content problem and the farmers' and mill plants' dislike towards machine operation.

Heavy crop condition, 30 to 50 tons per acre, or even 60 tons in special case relating to Thailand's sufficient sunshine and tropical weather, makes it hard for the chopper harvester to effectively dispose off mixed trash sans burning the cane. The mixed trash further worsens the loading density of untidy chopped stalks that reduce transportation efficiency to an unacceptable state for some truck drivers.

The sugar industry's trash consideration is another issue which passively influences the encouragement for machine use. High trash mixture exacerbates the processing condition, aggravates machine wear chine operation's compacting effect on cane field. Ordinary cane planting cycle is three or four years in Thailand. Growers do not want their cane field to be rolled and compacted, or the cane root be split or damaged by heavy machine operation. While with manual harvesting, a good crop yield in the next crop season can be expected. At 550 Baht/ton in price, several tons decrease per acre in yield means the heavy loss.

In sum, the manual harvesting system will continue to play an important role in Thailand's sugar industry in the near future. Machine harvesting system will not succeed unless it can reach high economic performance and suit Thai farming practices. Research work for small- to medium-sized sugarcane harvesters should direct on appropriate power selection, on de-trashing patterns and on ideal stalk transporting and handling method in harvesting.

(Continued on page 66)

Table 4. Economic Performance of Kampeng Phet, Thailand Average and Australian Cane Harvesters

	Kampeng Phet	Thailand average	Australian
Unit number in use	36	219	985
Unit capacity(ton/year)	7,900	8,500	39,500
Daily unit capacity(ton)	107	128	580
Fuel consumption (liter/tonnage-cane)	2.25	1.8	0.98
Total servicing time(h/year)	441	425	520
Average field length (m)	180	142	625
Head field (m)	1.85	2.2	4.8
Distance between rows(m)	1.45	1.32	1.52
Harvesting cost(Baht/ton)	125	105	72
Income(Baht/h)	1.79	N.A.	6,480
Income(Baht/ton)	90	92	90
Profit (Baht/ton)	-35	-13	18

Table 5. Percent Trash Content for Various Harvesting Systems (In%)

Trash type	Manual harvest (green cane)	Manual harvest (burnt cane)	Manual harvest (machine load)	Mechanical harvest			
				Kampeng Phet		Average Thailand	
Top	3.65	1.38 (4.26)	1.96(3.65)	10.44	(14.24)	4.72	(8.52)
Leaf	2.74	3.85	6.13	8.20		4.25	--
Root	--	0.09	0.12	0.11		0.03	--
Soil	--	1.12	2.35	--		--	--
Other	0.45	0.38	0.09	0.45		0.11	--
Total	6.84	9.70	14.3	33.44		17.43	

*Data in semicolon is the highest occurrence

Efficiency of Cotton Stalk Puller as Influenced by Forward Speed, Wheel Rotational Speed and Wheel Tilt Angle

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Abstract

Cotton is a versatile fibre crop, grown commercially in 111 countries throughout the world. India ranks first in cotton area, which constitutes 20 per cent of the world's cotton area but ranks third representing 12 per cent of the global production. Pulling the cotton stalk using a hand puller is slow, laborious and tedious. An investigation was carried out to mechanize the cotton stalk pulling. The developed unit consists of a gearbox for power transmission and a set of counter rotating pulling wheels. The power for pulling wheels was drawn from the tractor PTO shaft through gearbox. The developed cotton stalk puller was evaluated for its performance in terms of pulling efficiency and per cent breakage of cotton stalk at three levels of (i) forward speed of operation (1.2, 1.6 and 2.0 kph), (ii) wheel rotational speed (140, 180 and 220 rpm) and (iii) wheel tilt angle (10, 20 and 30 degree). The pulling efficiency was maximum at 1.2 kph forward speed of operation followed by mixed results at 1.6 and 2.0 kph forward speed of operations. The maximum pulling efficiency of 86.63 per cent was obtained at 140 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle combination. Minimum breakage of cotton stalk (7.74 %) was observed at 180 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle followed by 220 and 140 rpm wheel rotational speeds. It was observed that the stalk removal with cotton stalk puller resulted in 3.85 and 94.39 per cent savings in cost and time, respectively, compared to the manual method of cotton stalk removal.

Introduction

Cotton plant residue left in the field following harvest must be removed to prevent it from serving as breeding site for insects and diseases. For another reason, the cotton plant residue can produce considerable amount of thermal energy as it is used as a fuel. The annual removal of cotton stalk after harvest has been established as an essential operation in order to control the pests and diseases and involves considerable labour and money. Clearing the cotton stalk has three basic processes, namely; uprooting the stalk, gathering and stacking them and removing them from the field. Pulling of stalk using a hand puller is slow, laborious and tedious. Some of the farmers use repeated heavy disking to uproot and cut cotton plant residue and cover it with soil. The collection of cotton stalk manually to the desired extent requires 20 man-days per ha apart from being tiresome and time consuming. It has been proven that 15 to 20 per cent higher yields are possible with the mechanized sowing. This is possible if the field is free from

Fig. 1 Tractor-operated cotton stalk puller.

Fig. 2 Operational profile of cotton stalk puller.

stubble and roots. The problems faced by cotton growers in removing cotton stalk and forcing for mechanization are pulling cotton stalk. The production of tractors in India is the largest in the world. As a global power in the international tractor industry, India must ensure efficient utilization of such a heavy recurring investment in the agricultural engineering inputs. With this view, a tractor operated cotton stalk puller, if developed, will result in enhanced utility of tractors besides reducing the drudgery and eliminating the labour shortage during peak seasons.

Reveiew of Literature

Demian (1979) studied the existing pulling machines and root pullers and reported that the NIAE four-row pulling machine has two gauge wheels and power is through PTO shaft. The gripping and pulling devices are the two driven inclined pneumatic tyres. Kemp and Mathews (1982) developed a tractor mounted four-row machine for uprooting cotton stalk. The pulling principle of the machine is that of gripping the plant stem between a pair of counter rotating pneumatic wheels driven from the tractor PTO shaft and jerking it upwards by the combined peripheral motion of the wheels and forward travel of the machine. The eight pulling wheels were inflated to a maximum pressure of 4.8 bar rotated at 160 rpm by enclosed shafts, inclined at 45^0 to the horizontal. The work rates were in the range of 1.5 to 2.2 ha/h with pulling efficiencies in excess of 95 per cent. Sumner *et al., (1987)* evaluated the counter rotating wheel plant puller as a method to harvest cotton stubble from the soil. The existing two-row counter rotating wheel plant puller was modified by replacing the existing pulling wheels with smaller diameter tyres to minimize the height of the tyre contact point above the ground for pulling cotton plant stubble. The power is required to rotate the pulling wheels increased with a decrease in tyre pressure and increase in force between the wheels. Ben (1990) developed a machine (uprooter - shredder - mulcher) for cotton stalk harvesting. The U.S.M can be used to spread chopped stalk, to bury the chopped material into the soil and to have the chopped material blown through an elbow into an accompanying trailer.

Materials and Methods

The developed stalk puller consists of a gearbox, power transmission system and a pair of pulling wheels. The gearbox and pulling wheels were mounted on the centre of the main frame. The hitch point of the implement was shifted 0.375 m towards left when viewing from the rear side to make offset the implement. The power from the tractor PTO shaft was transmitted to a counter shaft through propeller shaft assembly and on to the gearbox input shaft using chain and sprocket (**Fig.1**). From the gearbox, the power is transmitted to the counter rotating pulling wheels through chain and sprockets to obtain the required speed. The ground clearance is adjustable from 0 to 100 mm using a float mechanism. The overall dimensions of the cotton stalk puller are as follows: length, 1,575 mm; height, 1,150 mm; width, 1,050 mm; and weight, 232 kg. The operational profile of the cotton stalk puller is shown in **Fig.2**. The developed cotton stalk puller was evaluated for its performance in terms of pulling efficiency and per cent breakage of cotton stalk evaluated at three levels of (i)forward speed of operation (1.2, 1.6 and 2.0 kph), (ii)wheel rotational speed (140, 180 and 220 rpm) and (iii) wheel tilt angle (10, 20 and 30 degree). The inflation pressure of the pulling wheels was maintained at 2.0 ksc throughout the field trials. The pulling efficiency and percent breakage of cotton stalk were computed from the data collected. The cost of mechanical

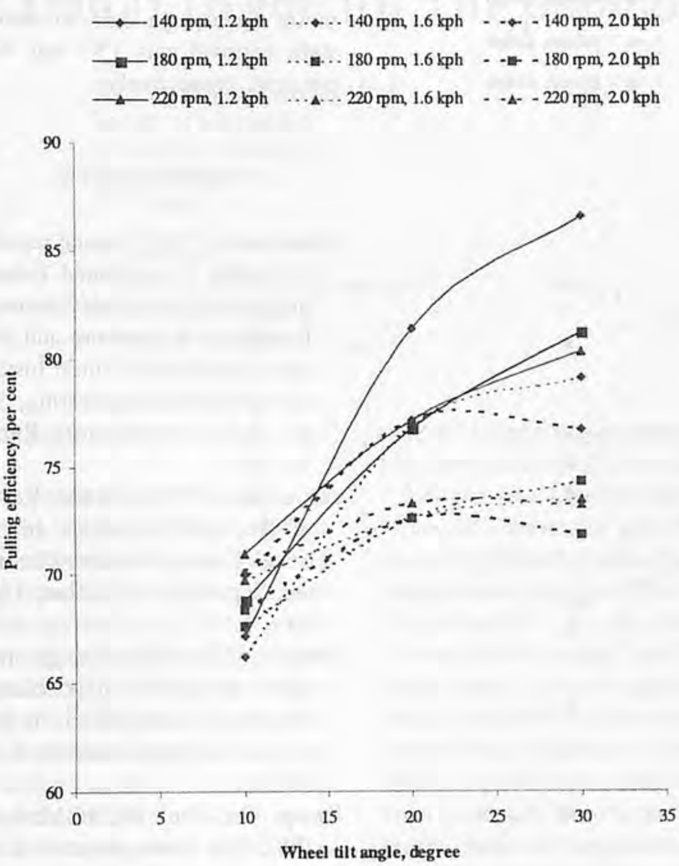

Fig. 3 Effect of wheel tilt angle on pulling efficiency at different wheel rotational speed and forward speed of operation

pulling with stalk puller was compared with manual method of cotton stalk removal. The cost and time saved by the cotton stalk puller against the manual method was compared.

Results and Discussion

Fig. 3 summarizes the effect of wheel tilt angle on pulling efficiency at different wheel rotational speed and forward speed of operation. It was noticed that the pulling efficiency increased with an increase wheel tilt angle. The 1.2 kph forward speed of operation displayed better pulling efficiencies followed by mixed results at 1.6 and 2.0 kph forward speeds. The pulling efficiency at 1.2 kph forward speed of operation and 140 rpm wheel rotational speed was 20 and 30 degree wheel tilt angles and the efficiency increased suddenly when the wheel tilt angle was changed from 10 to 20 degree and gradual increase in pulling efficiency when the tilt angle changed from 20 to 30 degree which indicated that further increase in tilt angle would not have that much effect on pulling efficiency. The wheel rotational speed of 140 rpm showed better results than 180 and 220 rpm wheel rotational speeds. The maximum pulling efficiency (86.63 %) was observed at 140 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle which indicated that wheel rotational speed and forward speed of operation should be minimum and wheel tilt angle should be optimum.

The effect of wheel tilt angle on per cent breakage of cotton stalk at different wheel rotational speed and forward speed of operation are summarized and showed in **Fig. 4**. It was observed from the figure, that 1.2 kph forward speed of operation resulted in low breakage of cotton stalk at 10 and 20 degree wheel tilt angle. At 30 degree tilt angle the breakage was less at the wheel rotational speed of 180 rpm and at 1.2 kph forward speed of operation followed by 220 and 140 rpm wheel rotational speeds respectively. The minimum breakage of cotton stalk (7.74 %) was 180 rpm wheel rotational speed, 1.2 kph forward speed and 30 degree wheel tilt angle combination followed by 220 rpm (9.23 %) and 140 rpm (9.80 %) wheel rotational speeds.

The comparison of cost and time requirements by the manual method of stalk removal and the prototype cotton stalk puller are showed in **Table 1**. The cost of removing the cotton stalk from one hectare field using cotton stalk puller was Rs. 2,326.00 whereas it was Rs. 2,419.35 for the manual method. The time required for removal of cotton stalk using cotton stalk puller from an area of one hectare was 13.55 hours whereas it was 241.93 man-hours in manual method. The stalk removal with cotton stalk puller resulted in 3.85 and 94.39 per cent savings in cost and time, respectively, when compared to the manual method of cotton stalk removal. Though the cost of operation with cotton stalk puller is almost equal to that of the manual method of stalk removal, it is highly efficient in terms of time savings and cleanliness of operation. It also eliminates drudgery in manual operation and alleviates problems of labour non-availability, the problem presently being experienced by cotton growers who even switched over to other easy crops.

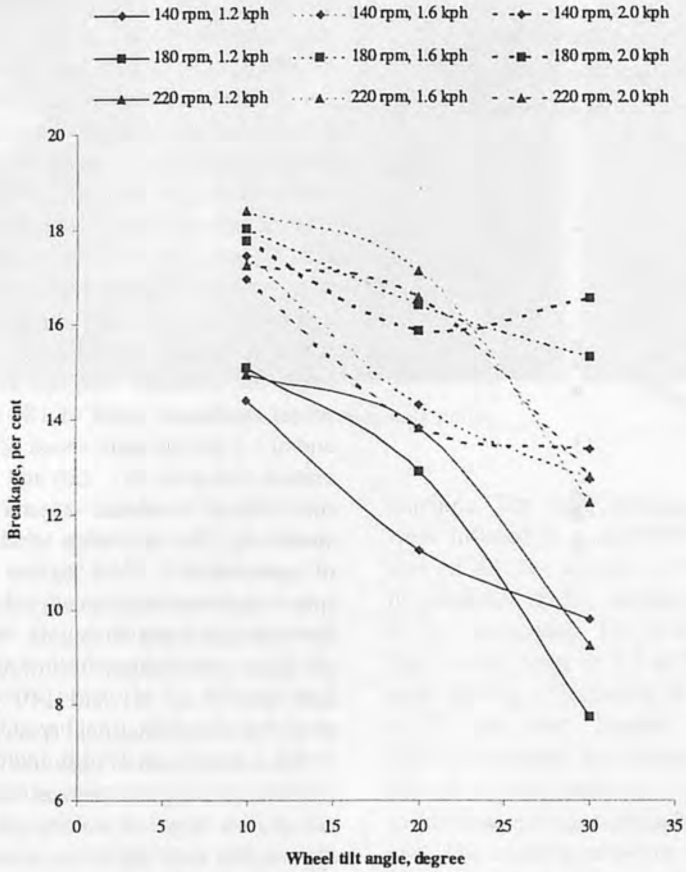

Fig. 4 Effect of wheel tilt angle on per cent breakage of cotton stalk at different wheel rotational speeds and forward speed of operation.

Conclusions

The pulling efficiency increased with an increase in wheel tilt angle. The pulling efficiency increased considerably when the wheel tilt angle was changed from 10 to 20 degree and increased gradually when the tilt angle was changed from 20 to 30 degree. The maximum pulling efficiency (86.63%) was obtained at 140 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle combination. The operation of the cotton stalk puller at 1.2 kph forward speed of operation resulted in better pulling efficiency when compared with 1.6 and 2.0 kph forward speeds. The per cent breakage of cotton stalk was reduced with an increase in wheel tilt angle from 10 to 30 degree. The minimum breakage of stalk (7.74 %) was 180 rpm wheel rotational speed, 1.2 kph forward speed and 30 degree wheel tilt angle combination followed by 220 rpm (9.23 %) and140 rpm (9.80 %) wheel rotational speeds. The cost and time saved by the cotton stalk puller in comparison to manual stalk removal was 3.85 and 94.39 per cent, respectively.

Table1. Abstract of Appraisal of Cost and Time

Method of cotton stalk removal	Cost, Rs. / ha	Time, h / ha	Per cent saving in	
			Cost	Time
Manual	2419.35	241.93	-	-
Mechanical	2326.00	13.55	3.85	94.39

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A Batch Dryer for Un-peeled Longan Drying

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Abstract

The performance of a modified batch dryer was compared to that of a conventional unit. Two thousand kilograms of fresh longan were used in each drying batch. The depth of fresh longan was 60 cm, the drying air temperature 75-80°C and the airflow rate 3.8 m^3/s (air velocity 0.7 m/s). Test results indicated that the modified dryer was more convenient to work with and required less turning time for longan inside dryer. The quality of the dried longan was uniform and did not differ from those dried in the conventional dryer.

Introduction

Longan is a major cash crop in northern Thailand. Some agriculturists have tried growing longan in other regions, but so far they have not succeeded. The weather conditions are a very important factor and in the northern regions, especially Chiang Mai and Lamphun provinces, they are most suitable for longan production. More than 75% of the total planted area in the northern region is in, and approximately 85% of the production volume of longan comes from, these two provinces (Anonymous, 1989).

Longan, which has the local name "Lumyai", commonly called "dragon eye" in English, is classified in the Sapindaceae family of fruit trees. The scientific name for longan is "*Dimocarpus longan* Lour." The longan fruit is nearly spherical in shape, the size of which range from 20 to 40 mm in diameter. When the fruit is ripe its outer skin is light-brown in color. It consists of a dark-brown stone of approximately 10 mm in diameter, which is covered by thick flesh. The flesh of the fruit is pale-white to light-pink in color with sweet taste measured at about 17-20% sugar by weight (Attabhanyo, 1977). However, the actual size, color and sweetness of the fruit vary. The edible portion is about 72% and the proximate analysis of the composition indicated 83.5% water (Nakasone and Paul, 1998).

The natural harvest period for this fruit is usually about one month. In order to have the fruit available throughout the year and reduce postharvest losses, several methods have been utilized to preserve the longan fruit, with the main one being drying. This method of preservation is most common because no special packaging is required and, due to reduced weight and volume, the shipping and storage costs are reduced. Two methods of drying longan are commonly practiced: 1) peeled dried longan, and 2) un-peeled dried longan. The method usually used by farmers is drying the fruit un-peeled. Batch drying in stationary beds affects the quality of dried un-peeled longan by over-drying the product at the bottom of the bed, thus, producing a non-uniform product. To overcome this problem and achieve almost uniform moisture, farmers turn over the top and the bottom layers during the drying process.

Normally, available longan dryers in northern Thailand measure about 2.35 m × 2.35 m × 1.00 m. They contain only one large tray for spreading longan fruit to a capacity of 2,000 kg for each drying batch. Most of them employ a diesel or gas burner, which is due to consideration for the aroma of longan fruit. The hot and dry gas (with a temperature of about 80°C and a velocity of about 0.7 m/s) will absorb the moisture from longan fruit as it passes through the bed. The common practice is to release the hot and humid gas directly to the ambient environment. Every batch needs to be turned over three times after about 12 hours to prevent over drying of the bottom part. But each time they are moved, some longan fruit become damaged, the shape deformed and the peel cracked.

Since longan is considered a major cash crop that brings in significant income to farmers in Chiang Mai and Lumpun provinces, research in different aspects of production and postharvest technology of this commodity is currently underway. Related to dryer design, a report

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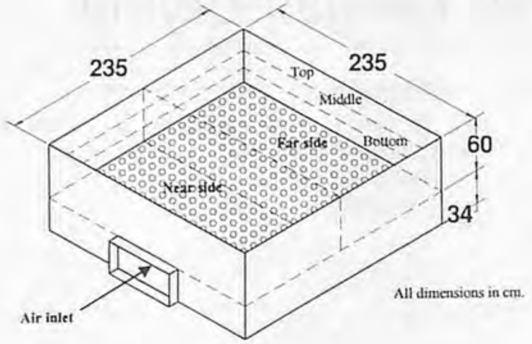

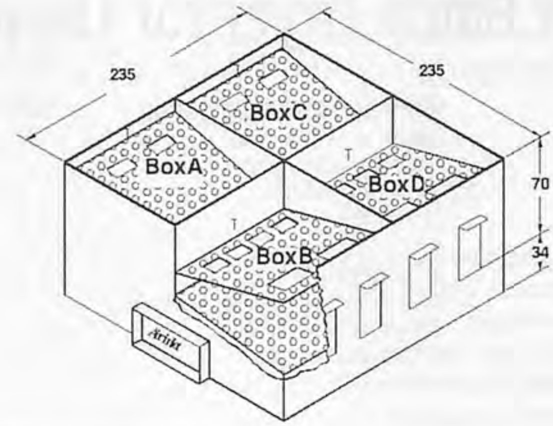

Fig. 1 Schematic diagram of the conventional dryer.

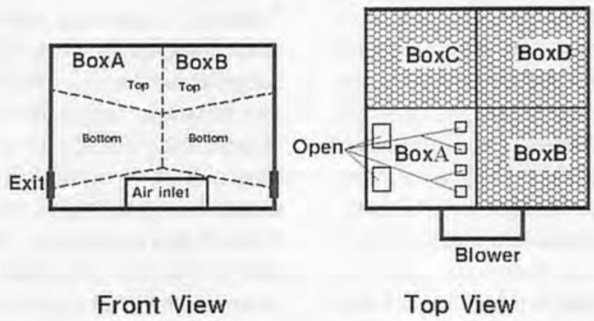

Fig. 2 Schematic drawing of the modified dryer.

by a team of researchers at Chiang Mai University (Anonymous, 1989) recommend using a dryer with several trays, and between the stages of drying changing the top and bottom trays. More recently, the second phase of the project, accessible on the IDRC website (www.idrc.ca), further supports the use of trays and rotation every 12 hours. Chaitep et al., (1999) studied the thermal effectiveness in air preheating by using a looped thermosyphon as a means of energy saving in longan drying. Based on a thermal effectiveness of 0.337 from laboratory tests, they concluded that the preheater unit was suitable for industrial scale applications.

The Institute for Science and Technology Research (1994) reported on the quality of drying longan and the growth of fungi. It was pointed out that at drying temperature of 80°C the fungi are not eliminated and if water activity is between 0.85-1.00, fungi can grow and affect the quality of the longan. On the other hand, if over-dried, the rehydration and texture of the product is affected. Therefore, optimum drying conditions are essential for achieving high quality dried longan.

The aims of this project were to design and construct an appropriate method for turning longan fruit during batch drying, compare the performance of the new dryer with an existing unit and evaluate the quality of products from the two dryers.

Materials and Methods

Materials

Two dryers were employed, one commonly used by farmers (referred to as conventional) and the other had new design (modified). Fresh longan was divided into two batches with each one containing 2,000 kg/dryer. **Fig. 1** is a schematic drawing of the dryer used by local farmers. The inside dimensions are 60 cm × 235 cm × 235 cm. A perforated metal sheet separates the plenum chamber from the bed of longan. Farmers divide the contents of the dryer into 3 layers by placing two separation nets. They also distinguish between the near side (closest to the air inlet) and far side (farthest from the air inlet). An oil burning unit is the source of energy for heating air. The hot air is passed through the bed of longan.

The new design has dimensions of 70 cm × 235 cm × 235 cm. The depth has been increased to ensure that the capacity (2,000 kg/dryer) is not reduced by the fixture of sloped, perforated iron sheets and the partitions. The dryer, shown in **Fig. 2**, has 8 compartments (4 on the top and 4 at the bottom). The supporting sheets of top and bottom compartments have a slope of about 10 % to facilitate the flow of material. The source of heat and air supply is the same as those used for the conventional dryer.

Procedure

In the conventional method two dryers are required, with drying and turning (mixing) being alternated between the two dryers. Loading the dryer also involves separation of the fruit (60 cm depth) into three layers by placing nets at depths of 20 and 40 cm, thus, identifying the three layers: bottom, middle and top. After 12 hours of drying, the heating system is stopped. The contents of the first dryer are then emptied into the second one. The longan in the top layer of the first dryer is moved to the bottom layer of the second dryer, and the middle layer again in the middle, with the longan from the bottom layer of the first dryer being moved to the top. Once again, the three layers are separated by nets. Every time the turning process is carried out, the fruit on the near side, i.e. closer to the burner, is placed in the far side and the fruit in the far side away from the burner is placed closer to the burner. This process of turning is performed three times in all, at 12 hour intervals, and the drying is complete in 48 hours. As pointed out, the general practice is to have two dryers available so that the second one receives the fruit in order to carry on the mixing and drying operations.

Larger installations have invested in heavy machinery and they use cranes to move each layer (about 600 kg) of fruit. But the majority of farmers use laborers and baskets to transfer the fruit from one dryer to the next. In the modified design the surfaces supporting the fruit are sloped and it is possible to have gravity flow. Another modification is the use of compartments so that the fruit can be moved from one part of the dryer to another without the need for a second dryer. In order to reduce the energy requirement in moving the fruit, the transfer is only between the lower and upper compartments and not horizontally (between the near and far sides). This process is shown schematically in **Fig. 3**.

A randomized complete block design (RCBD) with 3 replications was used for testing the quality of the final product. Three turnings at 12 hour intervals were assigned as treatments. The amount of fruit (2000 kilograms of fresh longan per batch), depth of longan (60 cm), drying airflow rate (3.8 m^3/sec) and temperature (75-80°C) were similar for both types of dryers.

Results and Discussion

In order to reduce the time of transferring the fruit from one dryer to another, four workers are generally employed who can complete this work in about one hour. However, the air blower is operated for one hour to cool the fruit down before the transferring starts. When considering the minimum number of workers, and ignoring the time taken for stopping the heating system in the dryer, the rotating time for the conventional dyers requires two men for two hours. Once the time and effort required by the small farmers was considered, a comparison of the performance of the modified dryer was made with that of local farmers who would use laborers, and not those who used cranes and mechanized systems.

In the modified dryer, the distance needed to move the product was shorter (upper and lower compartments of the same dryer) and the method of emptying its contents more convenient (gravity flow). It was evident that the labor requirement was reduced. It took about one hour for two workers to finish the job of turning over the fruit. The depth of fruit in each compartment of the modified dryer was less (about 30 cm) compared to that of the conventional dryer (about 60 cm). Therefore, there was a lighter load of fruit in the bottom layer.

Samples of longan from the four zones were tested for moisture content every 12 hours. The drying rate was comparable for the four zones of the modified dryer. The result for the conventional dryer was considerably different for the different layers. Obviously, without taking some measure to mix or turn over the fruit, over-drying of the bottom layer would be inevitable. With the current practice of mixing and moving the layers, which was followed in this study, the average values of final moisture content for products from the two dryers at the end of drying period were comparable. The moisture content of whole fresh longan (a mix of Grades AA, A and B) from an initial average value of 75 % (w.b.)

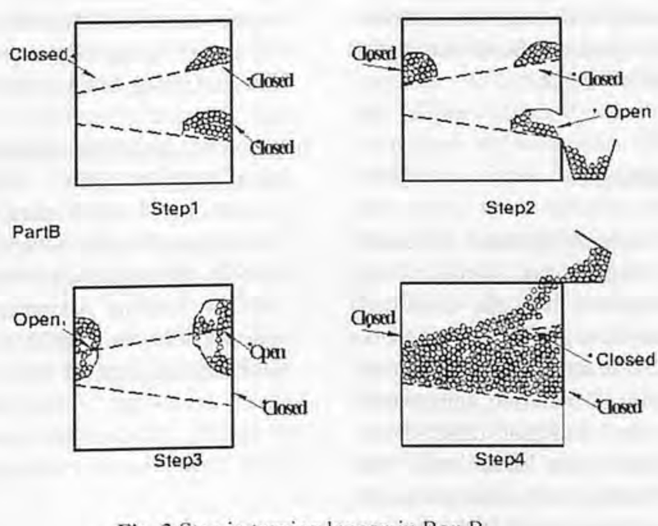

Fig. 3 Step in turning longan in Box B.

Table 1. Average values of Quality Indicators for Objective Analysis

Dryer	Average pH	Average A_w
New design	5.551^a	0.6067^a
Local dryer	5.057^b	0.4789^b
LSD	0.273	0.0454

Note: Numbers in the same column, but with different letters, indicate that they are significantly different ($p < 0.05$).

Table 2. Quality by Sensory Evaluation and Consumer Preferences

Dryer	Quality of longan				
	Color	Smell	Taste	Texture	Total
New design	5.18	5.25	4.55	5.23^a	2.93
Local dryer	4.90	4.80	4.35	4.23^b	2.58
LSD	NS	NS	NS	0.6762	NS

Note: Numbers in the same column, but with different letters, are significantly different ($p<0.05$).

was lowered to average values of 20.4 and 21.6% (w.b.), in the modified and conventional dryers, respectively. Detailed drying data and analysis of drying rates are presented in Phaphuangwittayakul (1998).

The quality of dried longan in both the new and conventional dryers was evaluated. Two approaches were utilized, viz., objective analysis and a taste panel. In the objective analysis, *pH* and water activity (A_w) of the products were compared. Results are given in Table 1. These analyses were carried out on the product 30 days after drying was completed.

Table 1 shows that the *pH* of longan from the conventional dryer is significantly lower than the modified unit, which could indicate a more acidic taste for the product. Comparison of water activity values led to the conclusion that the A_w values for product from the modified unit significantly higher than those from the conventional dryer, which could explain the reason for better texture.

Table 2 shows the result of the quality evaluation by the taste panel. Overall, the quality of the two products was comparable, except for the texture. The panelists preferred the texture of the longan fruit dried in the modified dryer. However, they did not observe a significant difference in the color of the two products. The products from both dryers (local and modified) had longan with low water activity, in which yeast, fungi and bacteria cannot grow.

The preliminary economic analysis calculated that the new turning procedure can save the costs for workers by $3/batch ($30/year, 10 batch/year/dryer), and the expenditure can be recovered in 6 years (costs to modify a local dryer $180/dryer). This calculation is based on modifying an existing dryer. The real benefit of the modified dryer is for small farmers starting a business in longan drying. With the conventional system, farmers need two dryers and four workers for moving longan. With the new system only one dryer is sufficient. The job of turning over longan in the new design can be handled by two workers. Therefore, there are significantly more economic benefits for the farmer when investing in the modified dryer.

Conclusion

The turning process for batch drying longan was studied. Test results showed that the modified dryer was more convenient to work with and less turning time required. The quality of the dried longan was uniform and did not differ from those dried in the local dryer. The costs of drying were reduced due to less labor being used. If the farmer modified his local dryer, it would cost him about $180 baht and the payback period for the investment would be 6 years, since the labor savings would amount to around 30 dollars per year (10 batches of drying per year).

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Spherical Biogas Plants for Rural Development

by
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Abstract

The utilization of biogas for making scientific use of organic waste is crucial for the sustainable upliftment of the poor. The use of biogas has multifarious advantages. The advantages of a biogas plant are not available, in its true sense, to the poor beneficiaries due to the high cost of construction of biogas plants. Such high cost plants are dependent upon the type and quantity of materials used for construction. Attempts have been made to design a suitable structure so as to utilize a minimum of materials that support the strength and durability of a masonry structure for the production of biogas. The spherical shape chosen as digester cum-gas storage space fulfils the requirements of a sound structural design, construction with minimum quantity of building materials, easy constructional procedure and cost effectiveness. Besides economizing, care has been taken to increase gas storage space for daily gas production from 33 % to 50 % which matches the requirement of most rural families and zero consumption hours. This model* has already been field tested over a period of more than five years and the results and responses are most encouraging.

*This model is popularly known as Spherical Konark Biogas Plant which probably derived its modified name from Konark village in E.Orissa where it must have originated.

Introduction

Rural development is currently accorded a high priority in almost all developing countries. The role of energy has become an essential component for the sustenance of all life forms with the growing sophistications and rapid industrial acceleration. The scientific use of organic waste to minimize the conventional energy consumption and optimize the use of available non-conventional energy source is biogas. When organic waste (cow dung mixed with equal proportion of water) is fermented anaerobically, biogas consisting of about 55 % of combustible methane gas is produced. Besides providing clean fuel and high quality bio-fertilizer it would help keeping the environment clean, providing motive power and bringing about qualitative change in the life style of the rural population, especially that of women. The heat energy available from the biogas is about 20 % more than that of biomass(cow dung). It also helps the reduction of indiscriminate felling of trees for fuel with its consequent deforestation. The fermentation of the input materials takes place in an airtight compartment. In a fixed dome plant the integrated structure is simultaneously utilized as digester cum-gas-storage space. The shape and positioning of different components of the biogas plant play a vital role while considering toughness, durability and reduction in cost of construction since it is a civil structure of masonry. After several trials and constant watching of the performance of the spherical shape over a period of more than five years, the specifications for different sizes have been standardized. The study of gas consumption pattern and zero consumption hours available to the rural beneficiaries optimized 50 % gas storage capacity of the model.

Technology Working Principle

In order to minimize the surface area, a spherical shape of a structure is desirable. The least surface area of a structure involves less materials consumption and hence the cost of construction is economized. The spherical structure of the Konark model acts as a digester-cum-gas storage space with sufficient empty space to accommodate unforced circumstances. Spherical structures when loaded from the convex portion remains under compression and, therefore, the internal load due to the self-weight of the slurry as well as the gas pressure counter balances and no residual effect on the structure is noticed. High gas storage capacity has been considered basing upon a study indicating the gas consumption pattern of average rural households. The storage capacity has been kept at 50 % to match the demand of the user and zero consumption periods. The use of construction materials is site specific and this model can be constructed with all types of building materials so far utilized for the construction of fixed dome biogas

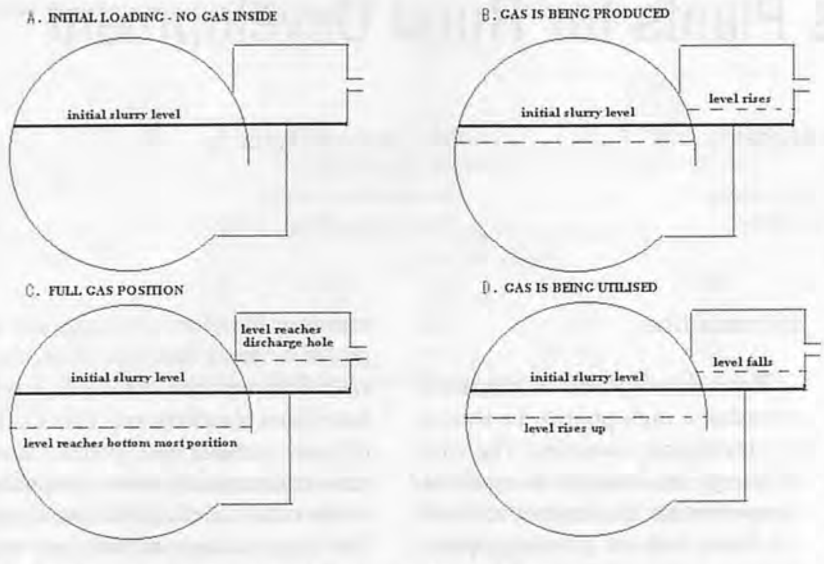

Fig. 1 Working principle of konark(spherical) biogas plant.

plants. The Konark model is constructed with ferro cement that shows encouraging results as far as economy and cost effectiveness are concerned.

During initial feeding of the plant, the slurry consisting of dung and water in a ratio of 1:1 is fed into the plant. Up to the level as shown in A, **Fig. 1**. After about 72 hours, fermentation starts and gas is accumulates in the empty space of the digester cum-gas-storage chamber. The gas thus generated exerts pressure on the slurry and the slurry inside the digester is displaced into the outlet displacement chamber. Thus the initial slurry level is lowered down inside the digester and the level of the slurry in the displacement chamber rises up. This process continues until the level in the digester reaches the upper end of the slurry discharge hole. This position exhausts the maximum gas storage capacity. Unutilized gas generated after this position expels slurry into the manure pit. When the gas is being used, the slurry that was displaced earlier into the outlet chamber returns back into the digester.

Assumptions

One kilogram of fresh dung produces 0.04 cu m gas.

The temperature for fermentation is in the range of 30 to 40 ℃.

pH for fermentation is assumed to be between 6.8 and 8.5 .

The carbon-nitrogen ratio of the slurry is around 30.

The dung and water ratio of the slurry is taken as 1:1.

The average rate of gas production inside the digester is 0.80 cu m per hour.

The plant has been constructed and experimented with 40 days hydraulic retention time (H. R. T.)

The course of gas production from one kg.of fresh dung is shown in the above histogram. It will be shown that beyond the 6th week gas production is minimum and uneconomical. This point was, of course, considered in designing the Konark model and its cost effectiveness.

As shown in **Table 2**, the consumption /demand of gas in the pre-lunch session is more than double than that in the pre-dinner session. Considering those facts and the maximum availability of zero consumption hours, 50 % gas storage capacity was designed for the Konark model.

Advantages of Spherical Konark Biogas Plants

Sound structural design.

Increased strength.

Spherical shape occupies least surface area, and uses minimum building materials hence economical structure.

Cost effectiveness as well as increased efficiency, when constructed using ferro cement technology.

Minimum consumption of cement, an expensive building materials.

Can be economically constructed with all kinds of building materials used in the construction of a fixed dome of biogas plants.

About 25 % less costly than the cost

Table 1. Courses of Gas Production

Week	Gas production (liters)	Cumulative (liters)
1st	36.50	36.50
2nd	26.20	62.70
3rd	17.70	80.40
4th	9.80	90.20
5th	5.60	95.80
6th	3.00	98.80
Total	98.80	

Table 2. Study on Gas Consumption Pattern in Rural Orissa

Session	Food Preparation	Prepared	Length of Time	Gas Quantity
Pre-lunch session	Tea	6 cups	10 minutes	0.075 cu m
(7.00 a.m. to	Parboiled rice	1 to 1.5 kg.	75 minutes	0.586 cu m
	Pulses-"dal"	200 grams	45 minutes	0.339 cu m
11.00 a.m.	Fry/curry/chutney	Approximate	30 minutes	0.226 cu m
	Sub-total		160 minutes	1.226 cu m
Pre-dinner	Tea	6 cups	10 minutes	0.075 cu m
Session	"Chapatti"	20 nos.	30 minutes	0.226 cu m
(6.00 a.m. to	"Dalma"/veg.Stew,	0.50 kg.	40 minutes	0.301 cu m
8.00 p.m.)	Fry/boiled milk etc.			
	Sub-total		80 minutes	0.602 cu m

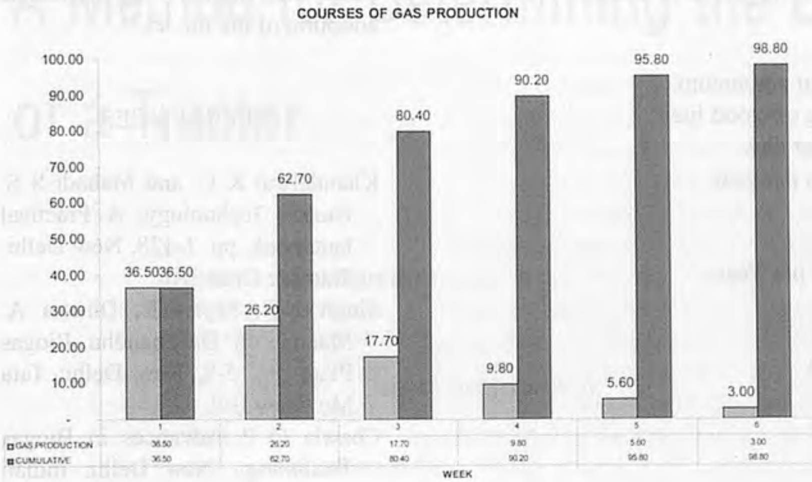

Fig. 2 Histogram of the courses of biogas production.

Fig. 3 Konark model biogas plant under construction.

of construction of popular Deenbandhu model with increased efficiency.

Gas storage capacity has been increased considerably to match the demand of the user.

Low gestation period.

Easy construction procedure.

Besides repaying the bank loan with interest, the beneficiary will be able to get Rs.1765.65 as surplus and after a period of 5 years he will be free from bank loan and avail himself of all the benefits generated from his installed biogas plant.

Fig. 4 Benificiary mixing cow dung with water in the mixing tank of Konark biogas plant.

Table 3. Comparative Cost Between 2Cu m, 40 days H.R.T., Janata, Deenbandhu and Konark Model Biogas Plant

Item	Janata		Deenbandhu		Konark	
	Quantity	Cost (Rs.)*	Quantity	Cost (Rs.)*	Quantity	Cost (Rs.)*
K.B.Bricks	2500 pcs.	3000	1000 pcs.	1200	600pcs.	720
Sand	3.5 cu m	280	3.00cu m	240	2.00 cu m	160
Chips	2.00 cu m	750	1.5 cu m	525	0.20cu m	70
Cement	25 bags	3750	14 bags	2100	8.5 bags	1275
A/c pipe	2.00 mtrs.	60	2.00 mtrs.	60	2.00mtrs.	60
Dome pipe	1 piece	20	1 piece	20	1 piece	20
Epoxy paint	1 liter	140	1 liter	140	1 liter	140
Plumbing, etc.	L.S.**	1000	L.S.	1000	L.S.	1000
Skilled mason	L.S.	600	L.S.	500	L.S.	450
Labour	L.S.	800	L.S.	700	L.S.	650
Miscellaneous	L.S.	600	L.S.	515	L.S.	455

* Rates quoted may vary 10 to 15 %.
**L.S.= Lump sum. Exchange rate:
Rs. 1.00 = U S $ 0.022.

Conclusion

With the decreasing quantity of fossil fuel, the renewable energy source is the only resort that mankind can bank upon. In order to make the rural development efforts more effective and advanced, there is an urgent need to best utilize the renewable energy sources by adopting updated, area specific, need-based family size biogas plants. It goes without saying that the spherical Konark model is superior to all other family-type fixed dome mod-

Cost-Benefit Analysis for a 2-cu m Konark Biogas Plant

Assumptions

Quantity of biogas produced:	600 cu m per annum.
One cu m of biogas	3.47 kg of wood fuel.
Loading rate	50 kg. per day.
Working efficiency	300 days per year.
Interest on bank loan	10 %.
Repayment period	5 years.
Availability of manure	10 tones per Year.

Cost Components

a. Cost of construction	Rs.5000
b. Central subsidy	Rs. 1800
c. Repair and maintenance	Rs. 250

Bank Loan Amortization, 15years

Principal	Rs. 3200.00/5
Interest (10%)	
1st. Year	Rs. 320
2nd. Year	Rs. 256
3rd. Year	Rs. 192
4th. Year	Rs. 128
5th. Year	Rs. 64
Total	**Rs. 960.00**

Total Annual Cost-

Installment towards principal	Rs. 640
Installment towards interest	Rs. 192
Repair and maintenance	Rs. 250
Cost of daily feed	
@Rs.0.15 /kg. for 15000kg.	Rs.2250
Total	Rs.3332

Annual Returns

a. Value of biogas in terms of wood fuel		
@Rs.180.00/quintal for 20.82 quintals		Rs.3747.60
b. Value of manure.		
Each plant will give		
100 kg. of nitrogen @ Rs.700/quintal	Rs.700.00	
50 kg. of phosphors @Rs.800/quintal	Rs.400.00	
50 kg. of potash @ Rs.500/quintal	Rs.250.00	
		Rs.1350.00
Total Annual Returns		Rs.5097.60

els insofar as they are developed and utilized for the production of much needed biogas. Its easy structural design, user's friendliness, cost effectiveness and easy time-saving installation would help the technocrats involved in biogas programme to render their efficiency and skill in an errorless manner. The rural beneficiaries of developing countries can derive much benefit from the role model which will contribute largely to rural development. The encouraging response and field results during the 5-year field trials at different geographical conditions in Orissa compels the authors to apprise all concerned to make wide publicity for immediate adoption of the model.

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A Method for Determining the Center of Gravity of a Tractor

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Abstract

This paper is about the description of the design and operation of a new device used to easily and accurately determine the location of the center of gravity of a tractor. The results obtained from experiments used to test the capability and the accuracy of the center of gravity determination device showed that it is satisfactorily capable of providing an accurate location of the center of gravity of a tractor. The center of gravity of a tractor was determined using the device and using the weighing method and the two were compared. The differences between the results obtained by the two methods were very small and confirmed the ability of the determination device to provide high quality location of center of gravity data. This portable device allows for easier and more accurate measurements to determine the location of the center of gravity of a tractor compared to currently used methods. It has the benefit of better accuracy, reduced operator effort, and improved speed.

Introduction

Tractors are being used for an ever-increasing variety of jobs around the farm. This increase use in both field and non-field operation has resulted in an increase in tractor upsets with consequent increase in operation injuries. As a result, there is considerable interest among farmers, manufacturers and safety engineers improvement in tractor design which may make tractor upset less likely to occur or less injuries the operator when they do occur.

It is necessary to locate the center of gravity, which is defined as the point at which the total weight of the tractor may be considered as acting. The location of center of gravity is of prime importance to any analysis of the forces which act upon the tractor and which affect its stability.

Since most tractors are composed of many comparatively irregular shape parts, it is rather difficult to analytically find the center of gravity of an assembled tractor. Although in a new design the center of gravity should be estimated before construction is started. However, the center of gravity may be located experimentally. It is necessary to determine only three planes each containing the center of gravity and each intersecting the other two. Because most tractors are approximately symmetrical with respect to a vertical plane perpendicular to the axles midway between the wheels, the center of gravity will be in this plane.

Several methods are commonly used to determine the center of gravity location. Among these methods, the following are used the most: suspension, balancing, weighing, and two-pendulum. In the suspension method, the tractor is suspended from a single point of support by chains or other suitable means (McKibben, 1927). Lines drawn on the side of the tractor to establish the center of gravity are drawn when the tractor is in a tilted position and are located through the point of suspension. A transit placed carefully at right angles to the centerline of the tractor may be used to conveniently locate these lines. The difficulty of establishing and maintaining a right angle between the center line of the tractor and the line of sight, together with the weight of the chains used to support the tractor, may result in a considerable error in establishing the height of the center of gravity.

The balancing method is similar to the suspension method, except that the point of support is below the center of gravity of the tractor instead of above it (Barger et al., 1963). Errors due to the use of a transit are the same as in the suspension method. In addition, however, wheeled tractors need to be balanced on some type of balancing platform which ordinarily introduce another source of error since the platform must be balanced in all positions of tilt or the effect of any change of platform balance with changes of tilt will influence the final result.

The weighing method involves a determination of the change of weight from front to rear (or vice versa) as the tilt of the tractor is changed. From this shift of weight and from the height of lift of one end of the tractor or the other, together with pertinent dimensions pertaining to the tractor, the height of the center of gravity may be determined (Barger et al., 1963).

In the two-pendulum method, the tractor is suspended by chains which are assumed to be of a negligible mass as compared to the tractor. The center of gravity is determined from the period of oscillation when the tractor is swung first as pendulum of one length and then of another (Brink, 1953a; Brink, 1953b; Heldt, 1952). The two-pendulum method is difficult to use because of the difficulty of lifting the tractor and physically suspending it as pendulum.

Tractor tipping behavior has been studied for many years using mathematical models. One of the first researchers to work in this area was McKibben (1927). Part of his work was continued by Worthington (1949) and Sack (1956). Pershing (1966) was among the first to use computers to solve the equation involved in the mathematical models. Goering and Buchele (1966) also developed mathematical models of a tractor and solved them on a computer. Their simulations were verified in the field by Kock et al (1968). Smith (1969) conducted the first research on complete rearward overturning which involved computer simulation and field tests for verification.

Objectives

The purpose of this study was to describe the design and operation of a simple and portable device used to determine accurately and easily the location of the center of gravity of a tractor (**Fig. 1**). The device was used to locate the center of gravity of a tractor and the results were compared with the results obtained using the weighing method. A main benefit of the device over the other methods it is easy to use and the results can be obtained quickly and accurately.

Theory

In general, three intersecting planes are needed to determine the center of gravity of a tractor. The first plane is the vertical plane in the longitudinal direction that is perpendicular to the axles midway between the wheels. The second plane is the vertical plane that is at right angle with the first plane in the transverse direction. The second plane is easily determined when the tractor is in ground level by taking the moment about the rear wheels. The third plane is the vertical plane with respect to ground when the tractor is in the raised position. The point of intersection of the three planes is the center of gravity of the tractor.

As shown in **Fig. 2**, the third plane can be determined by taking the moment about the rear wheels by using the following equation (Barger et al., 1963):

$X'_2 = R'_1 X'_1 / W$ .... (1)

where:

X'_2 = the horizontal distance between center of gravity and rear wheels when the tractor in the raised position (location of the third vertical plane), cm. It is denoted as X_2 when the tractor is at ground level.

W = the total weight of the tractor, kg.

R'_1 = the weight component on front wheels when the tractor in the raised position, kg. It is denoted as R_1 when the tractor in the ground level.

X'_1 = the horizontal distance between the front and rear wheels when the tractor in the raised position, cm.

The value of X'_1 can be determined using the following equation (Barger et al., 1963):

$X'_1=[X_1+(d_1-d_2)\tan \beta_1]\cos \beta_2$ ..(2)

where:

X_1 = wheel base of the tractor, cm.

d_1 = diameter of front wheel, cm.

d_2 = diameter of rear wheel, cm.

β_1 = the inclined angle of the tractor, degree.

Materials and Methods

Design and Operation of the Center of Gravity Determination Device

The purpose of this paper is to describe the design and operation of a center of gravity determination device that is used to locate accurately and rapidly the center of gravity of a tractor.

The center of gravity determination device (**Fig. 1**) was designed in the workshops of Jordan University of Science and Technology to overcome the difficulty encountered by currently used methods for determining the center of gravity of a tractor. **Fig. 3** shows a diagram of the device. It consists mainly of load cell, jack, two power screws, rectangular tubes, and strain indicator. The load cell is wired to a strain gage indicator and is placed on the lower end of the jack. The readings of the load cell indicate the weight of the tractor under the front wheels. The horizontal tube acts as the base of the device and is made of steel because of its durability. The tube dimensions are 10-cm high, 10-cm wide, and 170-cm long. The base power screw is inserted into the horizontal tube and operates manually. Two other vertical tubes, the frame vertical tube and the base vertical tube, each of dimensions 110 cm high, 4 cm wide, and 8 cm long can move relative to each other and are connected to each other by a screw. The base vertical tube moves horizontally on the horizontal tube by the base power screw. The frame vertical tube is welded to a horizontal steel arm at right angle at its upper end and is welded to a set of two curved round tubes at its lower end. The steel arm is 80 cm in length and has a vertical power screw, the arm power screw, mounted at its free end. The curved round tubes and the arm power screw are used to tighten the frame vertical tube with the frame of the tractor. The frame vertical tube used in this study together with its horizontal steel arm and curved round tubes are shown in **Fig. 4**. The complete assembly of the center of gravity determination device is shown in **Figs. 1** and **3**.

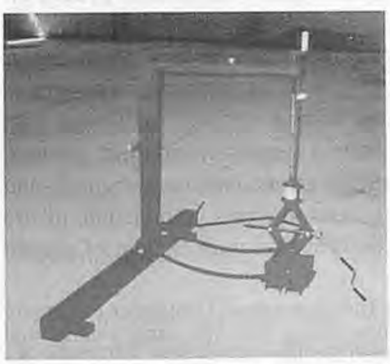

Fig. 1 Photograph of the center of gravity determination device.

Test of the Center of Gravity Determination Device

The experiment described below was designed to compare the center of gravity of a tractor obtained by the center of gravity determination device with the center of gravity of the same tractor obtained by the weighing method.

The first step in the experiment was to calibrate the load cell. A calibration curve and an equation were obtained for different loads and strain readings. The equation was used to convert the strain indicator readings in micro-strain to weight readings in kg. Then the load cell was placed in its position and both tractor and device were leveled. The strain indicator was then connected to the load cell as shown in **Fig. 5**. The jack was raised until the front part of the tractor was about to leave the ground. The first strain gage reading was taken and recorded at that moment. This reading represents the magnitude of the tractor weight component on the front wheels at zero degrees with the horizontal (R_1). After that and using the previous reading of the weight component (R_1) and equation 1, the horizontal distance from the rear wheel to the center of gravity of the tractor (X_2) was determined. This gives the location of the second vertical plane which represents the longitudinal location of the center of gravity of the tractor. Then the arm power screw was lowered and tightened on the first surface encountered on the top of the tractor (**Fig. 6**). After that, the screw connecting the frame vertical tube and the base vertical tube was loosened. The front wheels were then raised 16.5 cm using the jack and a second reading of strain indicating weight of tractor in the raised position (R'_1) was obtained. This second weight component on the front wheels (R'_1) was plugged in equation 1 to determine the location of the third vertical plane (X'_2). This location is the horizon-

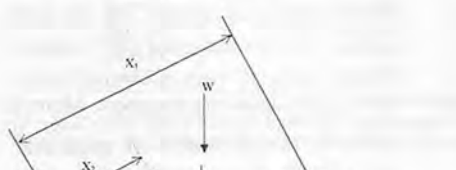

Fig. 2 Establishing a second and a third vertical intersecting planes in location of center of gravity by the weighing method.

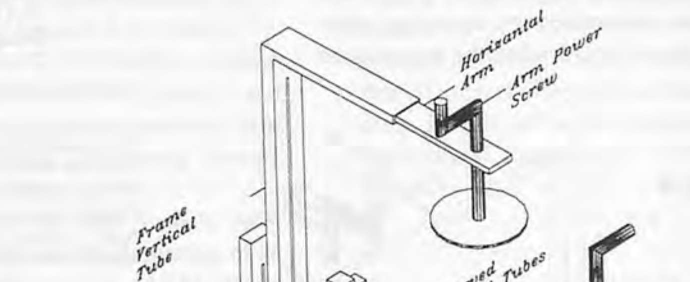

Fig. 3 Diagram showing the main parts of the center of gravity determination device.

tal distance between the center of gravity and rear wheels when the tractor in the raised position. Then the base vertical tube was moved horizontally by the base power screw to a distance of X'_2 to intersect with the frame vertical tube at a point. This point of intersection, which is the screw connecting the two vertical tubes, represents the vertical location of the center of gravity. Because of the symmetry of the tractor around the first vertical plane that is perpendicular to the axles of the wheels, the transverse location of center of gravity can be determined easily. The center of gravity of the tractor as a point is the point of intersection of the three planes (**Fig. 7**). The experiment was repeated ten times and the results are shown in **Table 1**.

Results

The center of gravity of a tractor was determined using the device and using the weighing method and the two were compared. Using the weighing method, the second plane containing the center of gravity can be determined by applying equations 1 and 2 when the tractor is on ground level. In this case, the weight component on the front wheels was 515.6 kg, the total weight of the tractor was 1500 kg, and the wheel base of the tractor was 158 cm. Then by applying equation 1, the second vertical plane was 54.3 cm forward to the rear wheels (X_2). The third vertical plane was found by raising the front wheels a distance of 16.5 cm and then the weight component on the front wheels was determined using the load cell and strain indicator. The weight component was 493.7 kg. The angle β_1 was measured to be 6°. Then by applying equations 1 and 2, the third vertical plane was 52.4 cm forward to the rear wheels and parallel to the horizontal surface (X'_2). The intersection of the three planes located the center of gravity of the tractor. This location was satisfactorily indicated by chalking the lines of the planes on the side of the tractor. The experiment was repeated 10 times and the results are shown in **Table 1**.

Comparisons of the location of the center of gravity of the tractor determined using the weighing method with the values obtained by the determination device are shown in **Table 1**. The differences between the results obtained by the two methods were very small and confirmed the ability of the determination device to provide high quality location of center of gravity data. A statistical analysis was performed at a 5% level of significance on the measured data for each determination method in each location component using the statistical software MINITAB (1994). The null hypothesis was that the measured data for each determination method in each location have the same mean. In general, there were no statistical differences among these sets of data for each determination method in each location component (**Table 1**).

Possible reasons for the none exact match of the location of center of gravity of the tractor determined by the two methods may arise from certain error-contributing factors. Such errors include weighing and measured errors, and change of tire deformation with change of weight

Table 1. Comparison Between The Location of The Center of Gravity of The Tractor Obtained Using The Weighing Method and Using The Determination Device*

Location component	Location of the center of gravity of the tractor (cm)	
	Using the weighing method	Using the determination device
Longitudinal location	54.3(a)	55.2(a)
Transverse location	50.0(b)	50.0(b)
Vertical location	68.0(c)	67.1(c)

*Means represent 10 measurements in each location component. Means in rows, within a location component, followed by the same letter were not significantly different at a 5% level using Tukey's Studentized range test.

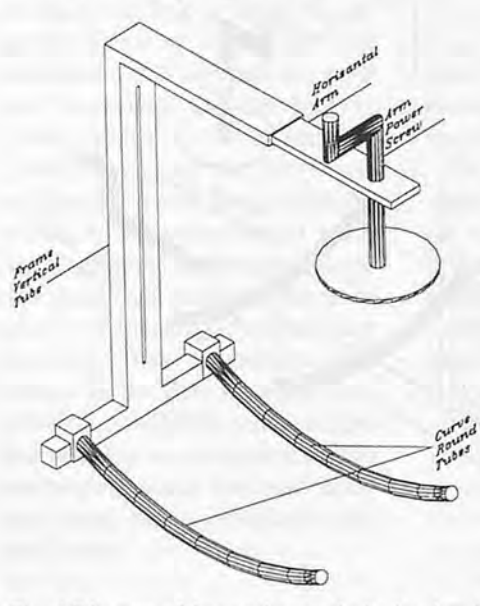

Fig. 4 Diagram of the moving vertical tube showing its main parts; the horizontal steel arm and the curved round tubes.

Fig. 5 Photograph showing the strain indicator connected to the load cell.

Fig. 6 Tractor operators tightening the moving vertical tube on the tractor by lowering the power screw to encounter the first surface from the top of the tractor.

Fig. 7 The device in action-view from the side. The tractor in its raised position resulting in an angle between the fixed and moving vertical tubes.

on the rear tires when the tractor is tipped. Also, another error might be introduced due to the flow of fluids within fuel, water and oil compartments of the tractor as different degrees of tilt are attained. Care should be taken to eliminate weighing and measured errors. Also, if an average of several weighings is taken, the effects of other errors may be satisfactorily eliminated.

Conclusion

The objective of this study was to describe the design and operation of a new device used to easily and accurately determine the location of the center of gravity of a tractor. The longitudinal and transverse locations may be quite readily and accurately determined by weighing the tractor in a level position. The vertical location may be found by tilting the tractor a certain angle. The results obtained from field experiments used to test the capability and the accuracy of the center of gravity determination device showed that it is capable of providing satisfactory determination of the location of the center of gravity of the tractor. This portable device allows for easier and more accurate measurements to determine the location of the center of gravity of a tractor compared to currently used methods. It has the benefit of better accuracy, reduced operator effort, and improved speed.

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Energy Requirement in Lac Production

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Abstract

Lac is a natural resin that is the secretion and protective covering of tiny lac insects *Kerria lacca (Kerr)* which is produced mainly in India, Thailand, Indonesia, Myanmar and China. *Butea monosperma* (*palas*), *Zizyphus mauritiana* (*ber*) and *Schleichera oleosa* (*kusum*) are the major commercial lac host trees in India. Mostly it is the tribals in Jharkhand, Chhattisgarh, W.B., Maharashtra, M.P., Orissa, Gujarat and Assam that undertake the production. About 3 million people are engaged in the production of lac in India. On an average, India produces 18 thousand tons of lac per year. It is an export-oriented product. Some 80 % of the country's total production is exported that earns about US$16-22 millions as foreign exchange annually.

Lac production involves a very simple operation that does not require any skill and requires less time than other agricultural operations. The pruning of host trees, bundling of broodlac twigs, tying of broodlac on trees for infestation, removal of used up broodlac sticks (*phunki*) from trees, harvesting of crop and lac scraping are the basic operations in lac production. These operations are carried out manually with the help of locally available traditional tools. The energy requirements in the production of lac from *palas*, *ber* and *kusum* were 11.68, 3.33 and 4.71 GJ/t in the first year and 10.25, 2.94 and 4.00 GJ/t in subsequent years.

The specific energy requirements in lac production from different lac hosts are comparable with specific energy requirements in the production of paddy, maize, wheat and gram. However, the returns from per ton of lac is several times higher than the returns from the crops cited above. Human energy only is the input used in lac production unlike crop production where, apart from human energy, animal, mechanical and electrical energies and a variety of services such as post-harvest technology are used.

With a view to meeting an increased demand for lac in the global market (being a natural and eco-friendly product) hence generate additional employment, it is important to promote lac production should be promoted.

Introduction

Lac is a commodity of very great antiquity and has been used for a thousand years as medicine, dye or resin. Currently, lac is only occasionally used for medicinal purpose. Its major application remains as a resin in a large number of modern industries.

The lac insect starts life as a larva (**Fig. 1**). It is ovate in outline, slightly more pointed posteriorly, soft-bodied, crimson in colour and very small in size being usually 0.6 mm long (excluding the antennae and caudal setae) and 0.25 mm wide across the thorax. Lac is secreted only by the female lac insects that secrete significant amount of resign only after fertilization. A large number of small lac glands found all over the body of the insect, pours out the lac resin continuously throughout its life forming a protective covering for the delicate and sedentary insect. As it is sedentary in nature during a large part of its life cycle, the quantity of lac secreted per insect is very small and requires approximately 300,000 insects to produce a sufficient quantity of raw lac to make one kg of shellac (refined lac in flake form). (The name shellac/varnish must have originated from "lac as shell covering".)

Lac is the only resin from animal source that possesses certain peculiar properties that make it a versatile natural resin, lending itself to diverse application, e.g., as a protective and decorative coating in the form of thin films, adhesive and plastics.

Two distinct strains of the lac insect are known in India, i.e., *kusmi* and *rangeeni*. These develop and mature in different seasons, and also prefer separate species of plants as their hosts. Both the strains of lac insects pass through two generations in a year and corre-

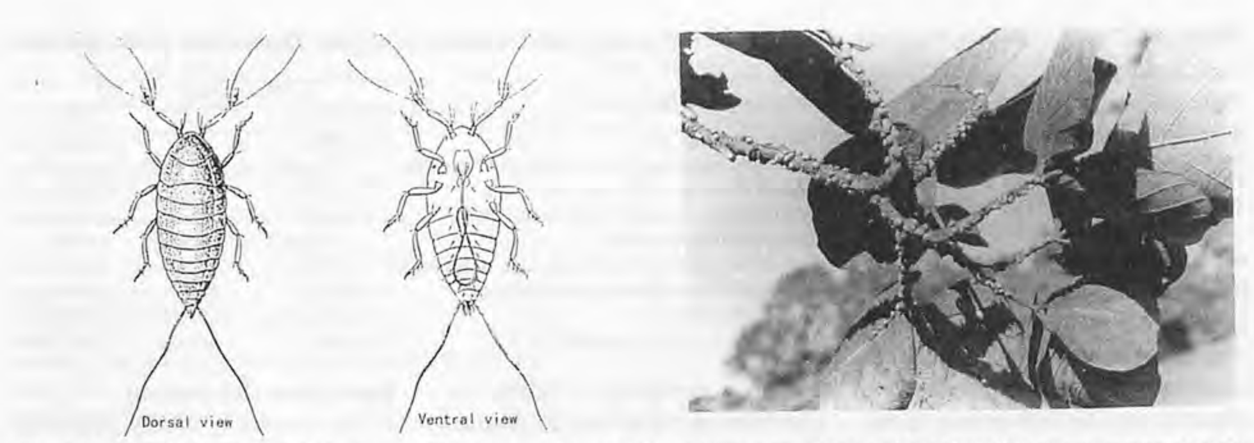

Fig. 1 Magnified sketches of the lac insect (*Kerria lacca, Kerr*), left, and lac encrustation on host plant (*Butea monosperma*), right.

spondingly yield two crops each. The lac crops from *kusmi* strain, about 6 months each, are called *jethwi* (summer crop) and *aghani* (winter crop). Similarly, the other strain known as *rangeeni* gives two crops, *katki* (rainy season) and *baisakhi* (summer crop), in a year but unlike the *kusmi* strain, the crops are of unequal duration, *katki* of about four months and *baisakhi* crop, on the other hand, is about eight months. In certain localized areas of Orissa and W.B. states of the country, trivoltine insect also breeds mainly on *Schleichera oleosa* and *Albizia saman* plants.

Over a hundred species of plants have been recorded as hosts for the lac insect in India, but only about a few of these are the commonly utilized species for lac production. They, in the order of importance are – (I) *Butea monosperma* (*palas*), (ii) *Zizyphus mauritiana* (*ber*) and (iii) *Schleichera oleosa* (*kusum*).

Palas is a medium-sized deciduous tree with a small and somewhat crooked trunk, occurring gregariously throughout the plains of India. It is about 5-7 m in height and 2.5-3 m in girth.

Ber is also a moderate-sized deciduous tree similar to *palas* but with a spreading rounded crown and drooping branches attaining 3-5 m bole and a girth 0.5-1m.

Kusum is a large, deciduous (nearly evergreen) tree with short trunk and spreading crown. It often attains a height of 7 m and a girth of 2.5 m or more.

The production of lac involves very simple operations and requires less time and a host of equipment than other agricultural operations. Pruning of host trees, bundling of broodlac twigs, tying of broodlac on trees for infestation with lac insect, removal of used up broodlac (*phunki*) from trees, harvesting of mature crop and scraping lac encrustations from stick are the major lac production operations.

In general, lac production operations involve climbing on trees. Thus pruning, tying of broodlac bundles on host tree at different places, harvesting and spraying of pesticides are done by male labourers, while bundling and selection of broodlac, collection of *phunki*, collection of harvested lac sticks and scraping of lac encrustation from twigs etc. are carried out by females.

A number of studies have been conducted to analyse agriculture energetics at various levels. Singh and Chancellor (1975), Maheshwari *et al.* (1981), Bohra and Maheshwari (1987), Singh *et al.* (1994), Tewari *et al.* (1987), Bohra *et al.* (1990), Singh and Singh (1991), Singh *et al.*, (1991), Mathew *et al.* (1998), Singh *et al.*(1994) and De (1998) studied the energy requirement assessment for crop production in India. Several other studies are also reported for energy requirement assessment for crop production in different countries i.e. Ezeike (1987), Hetz (1992), Bobobec (1992) and Akor and Ayotamuno (1995) for Nigeria, Chile, Ghana and Nigeria, respectively. Datta and Banerjee (1993) studied the energy requirement for the cultivation of betel vine in a typical village of West Bengal. Riva and Palaniappan (1989) and Yadav and Srivastava (1998) studied the energy requirements for processing green tea leaves. Joshi (1992) studied the energy requirements for different dairy farm operations.

In brief, several studies have been made to assess the energy input in India and abroad for agricultural crop production and allied agricultural

Table 1. Labour Requirement in Lac Production on Major Lac Host (for 100 trees)

Lac production operations	*Palas*		*Ber*		*Kusum*	
	Male	Female	Male	Female	Male	Female
Initial pruning	10	--	20	--	100	--
Selection, bundling and inoculation	8	4	15	14	50	38
Phunki removal and collection	4	4	6	4	18	8
Scraping encrustation (dry) from *phunki*	--	5	--	30	--	175
Spraying of insecticides	15	--	6	--	100	--
Harvesting, collection and selection	8	12	20	30	100	100
Scraping of encrustation from fresh lac	--	20	--	50	--	38
Total (First year)	45	45	67	128	368	359
Total (Second year onwards)	35	45	47	128	268	359

Table 2. Production of Sticklac per Year from 100 Lac Host Trees

Items	Lac production, kg		
	Palas	*Ber*	*Kusum*
Sticklac from fresh lac stick	50	800	800
Sticklac from *phunki*	60	--	1,400
Total	110	800	2,200

activities. However, no such work for lac production is reported. Therefore, there is sufficient scope for assessing the energy requirement and to understand the energy sources presently used by farmers in lac production. An effort has been made to compile and analyze the available information in order to determine energy used in lac cultivation.

Methodology

The data pertaining to energy requirement determination for lac production operation (**Tables 1** and **2**) were collected from available literatures (Jaiswal *et al.*, 2000, Krishanswami, 1960 and Mukhopadhyay and Muthana, 1962). The data for various operations collected during the study were converted into equivalent energy unit using conversion factors, i.e., man = 1.96 MJ/h, woman = 1.57 MJ/h and farm machinery (other than self propelled machine) = 62.7 MJ/kg for total life span of the machine (Verma *et al.*, 1994). *Dauli* (pruning knife), *Phunki* hook, secateur and sprayer are the most commonly used equipment in lac production operations.

Results and Discussion

The pruning, selection of broodlac, bundling, inoculation, *phunki* removal, pesticide application, harvesting and lac scraping are the major lac production operations all of which are carried out manually. Male labourers do the operations like pruning, inoculation, phunki removal, insecticide application and harvesting whereas rest of the operations are done by female labourers.

Table 3. Direct Energy Requirement per Year for Lac Production on Major Lac Host (for 100 trees)

Lac production operations	Direct energy use, MJ		
	Palas	*Ber*	*Kusum*
Initial pruning	156.8	313.6	1,568
Selection, bundling and inoculation of broodlac	175.68	411.04	1,261.28
Phunki removal and collection	112.96	144.32	382.72
Scraping encrustation (dry) from *phunki*	62.8	376.8	2,198
Spraying of insecticides	235.2	94.08	1,568
Harvesting, collection and selection of broodlac	276.16	690.4	2,824
Scraping of encrustation from fresh lac	251.2	628	477.28
Total (First year)	1,270.8	2,658.24	10,279.28
Total (Second year onwards)	1,114	2,344.64	8,711.28

The data pertaining to labour requirement per year for lac production on 100 trees are presented in **Table 1** which were used for the calculation of direct energy (**Table 3**).

The shares of indirect energy due to the use of tools and equipment were also calculated for different operations which are presented in **Table 4**. The energy requirement per ton production of lac is shown in **Table 5**. The results thus obtained are discussed below.

Pruning

The lac insects best thrive on tender shoots rather than on old and woody ones. In order to provide a suitable ground for the insect to feed well and thrive upon, the host plant must be receptive and sustainable. For young plants, no particular preparation is required to receive their first infestation since there is an abundance of tender shoots. For older plants however, a process of pruning is to be carried out prior to infestation in order to stimulate the production of fresh and succulent branches. Ordinarily, pruning is advisable only on branches less than an inch in diameter. The majority of farmers do pruning with the help of a pruning knife (*dauli*). In initial pruning of *palas*, *ber* and *kusum* direct energy requirements which were totally contributed by male labourer, were 1.568, 3.136 and 15.68 MJ/ tree whereas indirect energy requirements due to the use of tools were 50.1, 100.3 and 501.6 KJ/tree, respectively.

Inoculation (Infestation)

The process by which host trees are infested with the lac insects is known as inoculation. In this process lac bearing twigs from an infected tree are cut by male workers at maturity stage. Then female workers do the selection and bundling a few days before emergence of the larvae. The male workers tie the bundle of such twigs known as broodlac to an uninfected tree on which tender new shoots are plentiful. The larvae emerge out of the broodlac and settle down on young branches of the tree. In existing practice, inoculations are done manually. The direct energy requirement for this operation, which totally came through human labour, were 1.75, 4.11 and 12.61 MJ/tree for *palas*, *ber* and *kusum*, respectively.

Phunki (usedup broodlac sticks) Removal and Collection

The broodlac sticks left on the tree after insect emergence is popularly known as *phunki* lac. The optimum time of *phunki* removal is three weeks after inoculation. When broodlac is allowed to remain on trees even after emergence of lac insects, harmful insects carried along with broodlac from previous crop might invade new crops. Therefore, timely removal of *phunki* is necessary in order to prevent the carry-over of pests to new crops. *Phunki* is mostly removed from tree manually which again requires climbing on the tree. Bundle thus removed are either collected in bags or dropped on the ground. Some farmers also use inverted J shaped cutting hook

Table 4. Indirect Energy Requirement per Year for Lac Production on Major Lac Host (for 100 trees)

Lac production operations	Equipments used	Indirect energy, MJ		
		Palas	*Ber*	*Kusum*
Initial pruning	Big *dauli*	0.501	1.003	5.016
Selection, bundling and inoculation of broodlac	Secateur	0.08	0.28	0.76
Phunki removal and collection	*Phunki* hook	1.6	2.0	5.2
Scraping of encrustation (dry) from *phunki*	Small *dauli*	0.125	0.75	4.375
Spraying of insecticides	Sprayer	11.286	4.514	75.24
Harvesting, collection and selection of broodlac	Big *dauli*	0.4	1.0	5.0
	Secateur	0.24	0.6	2.0
Scraping of fresh encrustation	Small *dauli*	0.50	1.25	0.95
Total (First year)		14.732	11.397	98.541
Total (Second year onwards)		14.231	10.294	93.525

mounted on a bamboo-pole to pull down the bundles from ground level. The female workers collect the bundles thus removed. The energy requirements in this operation were 1.12, 1.44 and 3.82 MJ/tree for *palas, ber* and *kusum*, respectively.

Lac Harvesting

The removal of the stick-bearing mature lac encrustation is known as lac harvesting. The operation is similar to pruning. Farmers harvest the crop with the help of a sharp edge knife locally known as *dauli*. The harvested crop is collected and the lac encrustation bearing-twigs are selected with the help of a secateur, which is either used as broodlac or scraped. Male workers do the harvesting while the collection of harvested material and broodlac selection are done by female workers. The direct energy requirement in harvesting were 2.76, 6.9 and 28.24 MJ/tree for *palas, ber* and *kusum*, respectively.

Scraping

Lac scraping involves the removal of lac encrustation either from *phunki* (dried encrustation) or *ari* (fresh lac encrustation) lac stick. Female workers mainly scrap lac from lac sticks using the small *dauli*. The process is very tedious and slow. It involves sitting on the ground in groups and scraping by means of the small *dauli*. The direct energy requirement in lac scraping are 3.14, 10.04 and 26.75 MJ/tree for *palas, ber* and *kusum*, respectively.

The total direct energy requirement per tree for lac production on *kusum* is highest (87.11 MJ/tree) among the lac host trees, followed by *ber* and *palas*. This is due to the fact that *kusum* trees are larger in size than *ber* or *palas*. Among the lac production operations, scraping needs maximum energy, i.e., 3.14 and 10.04 MJ/tree, respectively, in the case of *palas* and *ber*. For harvesting, collection and broodlac selection in the case of *kusum* is 28.24 MJ/tree. Further contribution of indirect energy in lac production is negligible, i.e., 1.26, 0.43 and 1.06 per cent of the total energy use for lac production from *palas, ber* and *kusum*, respectively. This indicates that lac production operations are least mechanized. Only about 50 % of lac host trees are exploited for lac production. Though there is employment problem among lac growers, they do not prefer to be involved in lac production which requires climbing on the trees, a very cumbersome and dangerous chore. There is scope to bring more trees under lac production through mechanization of lac production operations and reduce drudgery of lac growers.

Table 5. Use of Energy in Production of Lac from Lac Hosts

Item		Energy use per ton production of lac, MJ/t		
		Palas	*Ber*	*Kusum*
Direct energy	1st year	11552.7	3322.8	4672.4
	2nd years onward	10127.2	2930.8	3959.6
Indirect energy	1st year	133.9	14.2	44.8
	2nd years onward	129.3	12.8	42.5
Total	1st year	11686.6	3337	4717.2
	2nd years onward	10256.5	2943.6	4002.1

The energy use per ton production of lac from *palas, ber* and *kusum* are 11,686.6, 3337 and 4717.2 MJ/t, respectively. The energy requirement in the case of *palas* is greater because *palas* trees are less productive than *ber* and *kusum*.

Comparative Energy Use in Lac with other Agricultural Crops

The energy requirement for lac production is comparable with those of agricultural crops like paddy, maize, wheat, and gram where energy requirements are 4.72, 8.11, 4.57 and 8.47 GJ/t, respectively (**Table 6**).

However, returns from lac production are several times higher than those obtained from agricultural crops. Only human energy is used in lac production unlike agricultural crop production where, apart from human energy, animal, mechanical and electrical energies are also used. As a result lac production generates more man-days of employment per ton on lac production than crops like paddy, maize, wheat and gram. With a view to meeting increased demand for lac in the global market (being a natural and eco-friendly product) and to generate additional man-days of employment, lac production should be increased.

Conclusions

1. The Energy requirements in lac production were 11.6, 3.3 and 4.7 GJ/t using *palas, ber* and *kusum* trees, respectively, which are comparable to energy requirements in agricultural crop production.
2. Indirect energy requirement in lac production was negligible

compared with total energy requirement in lac production which leads to a conclusion that lac production is least mechanized. Currently, majority of the operations in lac production are performed manually. As only 50 per cent of lac host trees are exploited for lac production, mechanization will help to bring more trees under lac production and reduce the drudgery among lac farmers.

3. Lac production generates more man-days of employment per ton of lac production than crops like paddy, maize, wheat and gram.
4. With a view to meeting increased demand for lac in the global market (being a natural and eco-friendly product) and to generate additional man-days of employment, lac production should be increased.

Table 6. Comparison of Energy Use in Lac Production with Other Agricultural Crops

Crop		Energy use, GJ/t
Agriculturalcrops	Paddy	4.72*
	Maize	8.11*
	Wheat	4.57*
	Gram	4.57*
Lac	*Palas*	11.68
	Ber	3.33
	Kusum	4.71

* As reported by De 1998.

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Status and Trend of Farm Mechanization in Thailand

by

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Abstract

Rice is the staple crop in Thailand and the total area planted to it covers about 60% of the total cultivated land in the country. Other crops are maize, sugarcane, cassava, soysbean, groundnut, rubber, oil palm and fruit crops. For over 35 years of the seven National Economic and Social Development Plans (1962-1996), Thailand has developed to be an industrial country. The labor force is gradually drawn out from the agriculture sector. Agricultural machinery and post-harvest technology were introduced to assist farm work and became an important inputs for agricultural production. Most types of farm machinery such as power tiller, planter, cultivator, thresher, combine-harvester, rice mill, dryer and water pump are locally made. Some of them are exported. Sophisticated machines such as tractors, sugar cane harvester and large-sized water pump are imported. Standardization of agricultural machines such as small diesel engine power tiller, rice mill, paddy thresher and rice combine harvester have been established. During the Eighth National Economic and Social Development Plan, (1996-2001) Thailand was confronted with economic crisis that resulted in a decline in the production of agricultural machinery for about 50%.

Research and development on agricultural machinery are conducted by the Department of Agriculture and universities and in corporation with local manufacturers. The distribution of agricultural machinery is conducted by the Department of Agricultural Extension whereas, the Department of Agriculture coorporates with local manufacturers. The Thai Society of Agricultural Engineering plays an important role in coorporating with government organizations and private sectors promoting farm mechanization.

Introduction

Thailand is one of the world suppliers of agricultural products. Around 63 percent of the total people about 57 million population live in the rural areas and most of them earn their living from farming. Approximately 41 percent of the total area or 514,000 sq km of the country is under agriculture. From a total of 17.5 million hectares of cultivated land or approximately, 14 million hectares are rainfed. Rice is the most important crop covering approximately 60 percent of the total land. Maize is the second important covering about 10 percent of the arable land. Other crops are rubber, cassava, sugarcane, mungbean, soybean, kenaf, groundnut and fruit crops. Area, production and prices of major crops appear in **Table 1**.

For decades, the agriculture sec-

Table 1. Planted Areas, Production, and Farm Prices of Important Commodities, during Crop Year 1998-01

Commodities	1998/99			1999/2000			2000/01		
	Area	Prod.	Price	Areas	Prod.	Price	Areas	Prod.	Price
Rice	10,032	22,999	5,756	10,311	24,172	4,679	10,502	25,608	4,621
Maize	1,441	4,617	3,690	1,248	4,286	4,290	1,259	4,397	3,790
Cassava	1,071	15,591	1,260	1,152	16,507	910	1,185	19,064	630
Sugar cane	918	50,332	470	945	53,949	446	867	49,070	491
Mungbean	303	226	12,700	322	249	11,100	304	233	12,580
Sorghum	98	146	2,560	88	142	3,650	92	148	3,060
Soybean	235	321	9,750	232	319	8,630	234	324	9,230
Groundnut	89	135	12,170	90	138	11,100	88	135	11,240
Oil palm	-	2,465	3,370	-	3,512	2,200	-	3,256	1,660
Rubber	-	2,162	23,060	1,548	2,199	18,050	1,563	2,236	21,520

Source: Agricultural Statistics of Thailand Crop Year 2000/01, Office of Agricultural Economics.

Note: Areas = '000 ha. ; Production = '000 ton. ; Price = Bahts/ton.

Table 2. Percentage of Gross Domestic Production, Previous National Economic and Social Development Plans

Sector	3rd Plan 1972 - 76	4th Plan 1977 - 81	5th Plan 1982 - 86	6th Plan 1987 - 91	7th Plan 1992 – 96	8th Plan 1997 – 01
Agriculture	25.08	21.36	9.01	14.88	11.42	11.29
Non-agriculture	74.92	78.61	80.99	85.12	88.58	88.71

Table 3. Population and Labor Force in Agriculture Sector, the 7th National Social and Economic Development Plan (1992-1996) and Trend in the 8th Plan (Unit: × 1,000 persons)

Year	Population				Labor Force			
	Agri.	Non-Agri.	Total	%in Agri.	Agri	Non-Agrc.	Total	%in Agri.
7th Plan								
1992	36,245	21,784	58,029	62.46	19,684	13,328	33,012	59.63
1993	36,540	22,143	58,683	62.27	19,833	13,546	33,379	59.42
1994	36,491	22,615	59,335	61.88	19,914	13,833	33,747	59.00
1995	36,855	23,130	59,985	61.44	19,969	14,146	34,115	58.53
1996	36,943	23,690	60,633	60.93	19,999	14,486	34,485	57.99
8th Plan								
1997	37,008	24,270	61,278	60.39	20,016	14,839	34,855	57.43
1998	36,948	24,974	61,922	59.67	19,959	15,265	35,224	56.66
1999	36,783	25,780	62,563	58.79	19,843	15,753	35,596	55.74

Source: Agricultural Economics Research Division, Office of Agricultural Economics.

Table 4. Land Uses, Yield, Water Resources, Farm Size an Agricultural Incomes by Region Year 1999

Item	Region			
	North	North East	Central Plain	South
1. Land use for agriculture (ha)				
- paddy fields	2,431,350	6,064,598	1,886,650	541,243
- field crops	163,479	2,059,018	141,310	14,878
- fruit tree and tree crops	316,457	381,239	727,453	2,145,890
- vegetable and flowers	51,437	38,986	48,543	14,304
- grass land	17,470	76,836	19,886	7,560
2. Farm size (ha)	3.61	4.07	4.95	3.62
3. Water resources				
- irrigated area (ha)	475,323	39,768	50,666	27,516
- average annual rainfall (mm.)	1,100.73	1,428.34	1,431.34	2,472.03
- paddy field under water pumping project				
- dry season (ha)	35,047	24,678	34,968	9,551
4. Yield of some major crops (tons/ha)				
- paddy - wet season	4.21	2.84	4.57	2.91
- dry season	2.63	1.73	3.08	2.11
- maize	3.53	2.95	3.54	2.41
- sorghum	1.64	1.42	1.56	-
- sugar cane	53.85	56.98	53.53	-
- cassava	15.08	14.92	16.84	-
- mungbean	0.81	0.66	0.66	0.63
- soybean	1.41	1.40	1.81	-
- groundnut	1.59	1.51	1.68	1.32
5. Cash farm income (US$/farm)	1,219	581	2,325	1,396

Source: Agricultural Statistics of Thailand Crop year 1998/99

tor contributed more than 20 percent of the gross domestic product (GDP). However, the contribution of agriculture in the country's GDP has declined for some years from 25.08 percent during the Third National Economic and Social Development Plan (1972-1976) to only 10.94 percent during the Seventh Plan (1992-1996) as shown in **Table 2**. Nevertheless, for national food security and the social structure, agriculture will remain to play an important role in the national development. As a consequence of the rapid expansion in other economic sectors, migration rate of labor force from agriculture sector had increased every year. It was the predicted that the percentage of agricultural labor force would decline to about four percent during next four years (**Table 3**). Therefore, agricultural labor shortage problem would become more critical.

The present 9th National Economic and Social Development Plan mainly aims at putting people and human resources at the center of development. Moreover, effective utilization, preservation, and rehabilitation of natural resources and environment are also being emphasized. The present Plan was greatly affected by the global crisis that resulted in labor migration back to the rural areas. These people were still waiting to go back to work in the city. This mseans farm mechanization and its effective utilization would still play a significant role during the present National Development Plan of the country.

Agricultural Mechanization Status

Agricultural machinery has become one of the most important inputs for the modern agricultural production system. Owing to cash income opportunities from other sectors, problems of labor shortage in agriculture boosted the mechanization level in the country. Even at the time of economic crisis, the demand for modern agricultural machinery is still high. The expansion differs from region to region. The statistics of land use, yield of important crops, farm size and agricultural incomes by region are shown in **Table 4**.

Based on farm income of farmers, the central region is the most progressive farm area of the country. In this area, the mechanization pattern is mostly characterized by power intensive operation machines such as single axle 2-wheel tractors, water pumps, and threshers. These machines are utilized for intensive operations such as seed drills, weeders, and more sophisticated and higher productive machines, which includes combine harvesters, stationary balers, dryers, etc. This can obviously be seen from the increase in production from seed drills and sprayers.

Most of the seed drills were sold in the farm areas and in the lower part of the northern region. Nevertheless, due to the increase of purchasing power, the old-model single axle two-wheel tractors (power tiller) which have no steering clutch or with only steering clutch but without gear transmission system were changed to tractors with steering clutch with more than 2 forward speeds and 1 backward speed. The 2-wheel tractor was modified to 4-wheel tractor.

The production of some machines not only expanded in number but also increased in size such as the paddy thresher whose original design size was 4-foot cylinder long and operated by 10-hp diesel engine with a capacity of about 1-1.5 ton per hour. Consequently, the size has been expanded. Recently, there were 8-foot cylinder long self-propelled models that use diesel engines for farm trucks (about 90-130 hp), producing a capacity of about 8-9 ton per hour, now available in the market, These large paddy threshers are mainly used on contracting works and have been modified to be able to handle soybean and other cereal crops. Although these large paddy threshers could assist farmers in intensive farm operations, the farming sector is still feeling the labor shortage for harvesting.

Since the central plain region is in the center of industrial development, many factories were established in rural areas nearby Bangkok. Due to better income and incentive from the industrial sector, farm labors tend to migrate to other sectors which increases every year. Locally produced rice combine harvesters were first developed and utilized in this region. Harvesters for other crops such as soybean, corn, sugarcane and others are all needed by farmers. It is obvious that appropriate machines will be rapidly and widely adopted and expanded. The Agricultural Engineering Research Institute (AERI), of the Department of Agriculture

Table 5. Mechanization Level in Production of Some Important Crops

(Unit: Percentage of Cultivated Area)

Operations	Crops			
	Paddy	Corn	Sugar Cane	Soybean
Ploughing	90	95	100	80
Planting	5	80	75	70
Irrigating	50	30	40	50
Weeding (spraying)	75	75	70	80
Harvesting	20	5	15	5
Threshing	90	90	-	90
Drying	10	20	-	5

Source: Estimation Undertaken by the Agricultural Engineering Division (This was changed to "Agricultural Engineering Research Institute (AERI)), Department of Agriculture (DOA).

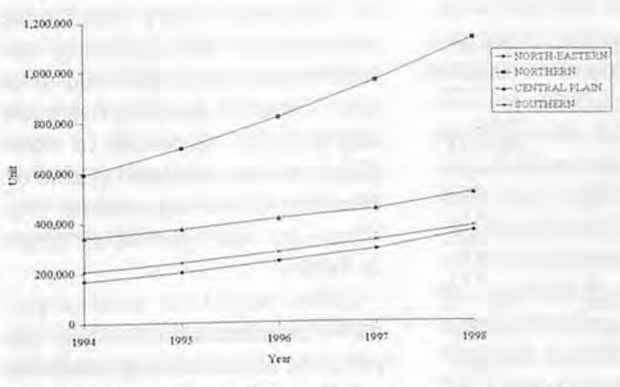

Fig. 1 Trend in numbers of 2-wheel walking tractors used in agriculture, by region, 1994-98.

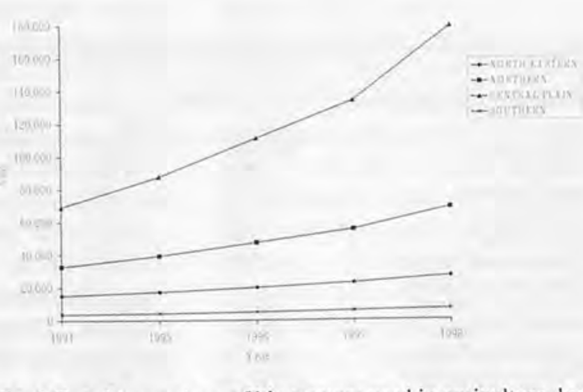

Fig. 2 Trend in numbers of big tractors used in agriculture, by region, 1994-98.

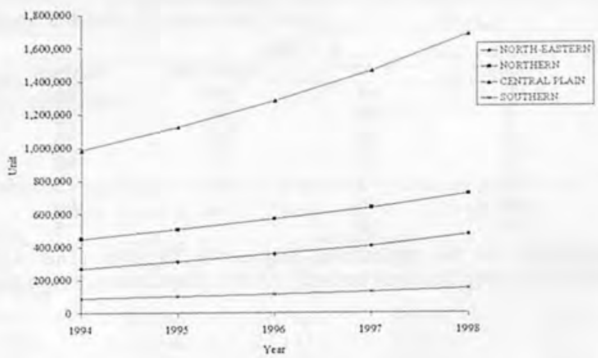

Fig. 3 Trend in numbers of water pump used in agriculture, by region, 1994-98.

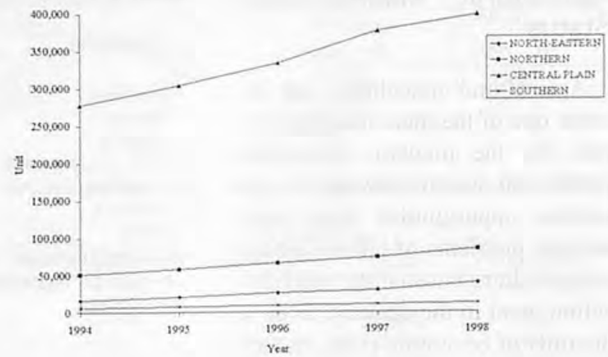

Fig. 4 Trend in numbers of hand-operated sprayers used in agriculture, by region, 1994-98.

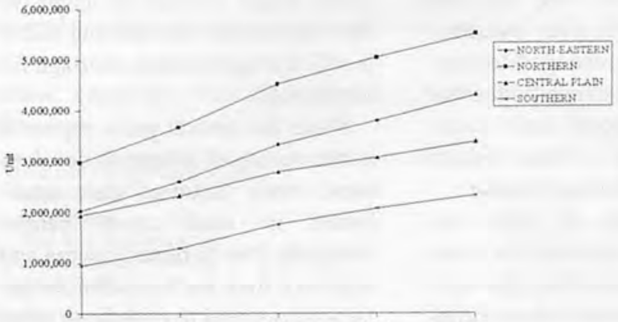

Fig. 5 Trend in numbers of machine-operated sprayers used in agriculture, by region, 1994-98.

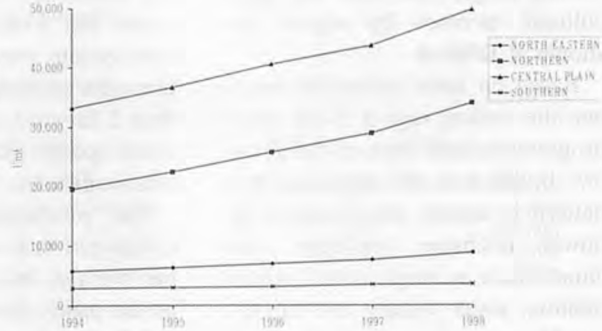

Fig. 6 Trend in numbers of threshing machine used in agriculture, by region, 1994-98.

(DOA) in collaboration with some local manufacturers are working on the development of some appropriate harvesters soybean reaper, corn picker, corn combine harvester, tractor-mounted whole-stick sugarcane harvester, etc.. Statistically, it should be noted that there are around 3,500 locally made rice combine harvesters and 60 imported sugarcane combine harvesters being used in the progressive farming regions of the country.

In other regions, mechanization expanded very rapidly in the pattern of power intensive machines, especially the single axle 2-wheel tractors, water pumps, sprayers, and threshers. The mechanization level of various farming operations for some major crops: paddy, maize, sugarcane and soybean is shown in **Table 5**.

Statistics of some common agricultural machines used of the entire kingdom are shown in **Figs. 1-6**. At present, majority is locally produced, only large tractors are entirely imported. There are some manufacturers reconditioning and reassembling imported used tractors. About 75 percent of sprayers and about 30-40 percent of water pumps are also imported (**Table 6**). However, some agricultural machines are also exported as shown in **Table 7**.

Efforts have been made to promote mechanization to help improve the socioeconomic conditions and National Development Plan of the country. Besides the AERI,

Table 6. Statistics of Imported of Agricultural Machinery and Equipment, 1998-99

(Value : × 1,000 US $)

Machinery and Equipment	1998		1999	
	Units	Value	Units	Value
Water pumps	947,981	75,506.1	2,274,723	68,624.6
Ploughs	395	134.4	380	35.9
Harrow, hoes	2,172	44.7	293	53.6
Cultivators	19	30.2	137	111.1
Distributors	130	27.1	17	20.2
Harvesting machines	529	125.8	16	71.6
Threshing machines	4	1.3	8	31.6
Cleaning machines	8,064	2,885.1	880	4,673.4
Poultry incubators	6,709	953.0	22,607	2,510.9
Spraying machines	66,933	4,121.9	136,933	566.9
Other farm machines	704,578	3,883.8	-	7,165.2
Farm tractors	5,390	27,206.7	383,716	39,092.6

Source: Agricultural Statistics of Thailand Crop Year 1998/99

Table 7. Statistics of Exported of Agricultural Machinery and Equipment, 1998-99

(Value : x 1,000 US $)

Machinery and Equipment	1998		1999	
	Units	Value	Units	Value
Spraying machines for pesticides	2,348	94,437	1,876	76.2
Ploughs	1,208	943.6	853	353.6
Water pumps	246,297	15,325.8	417,111	19,591.8
Other farm machines	24,446	1,755.3	118,414	1,500.0
Farm tractors	51,450	31,049.8	48,568	12,000.0

Source: Agricultural Statistics of Thailand Crop Year 1998/99

Table 8. Agricultural Machinery and Equipment Production, 1993-98

(Unit: Numbers)

Machinery and Equipment	1993	1994	1995	1996	1997	1998
Power tiller	70,000	85,000	100,000	100,000	80,000	40,000
Combine harvesters	400	200	400	400	300	100
Equipment for field preparation						
Ploughs for tractor	4,000	4,000	5,000	5,000	3,000	2,000
Ploughs for power tiller	80,000	100,000	120,000	120,000	90,000	50,000
Threshing machines	2,500	2,000	2,000	2,000	2,000	800
Planters	2,000	3,000	4,000	4,000	3,000	1,500
Corn sheller	600	600	800	800	600	400
Water pump	60,000	60,000	70,000	70,000	50,000	40,000
Sprayers	60,000	60,000	70,000	70,000	60,000	40,000

Source: Agricultural Engineering Division (AED), Department of Agriculture (DOA)

there are a number of universities such as Kasetsart University, King Mongkut's University of Technology Thonburi in the central plain region, Khon Kaen University in the northeastern region, Chiang Mai University in the north, and other technical institutes undertaking research and development on farm machinery.

At present, research and development on farm machinery is focussed on the research collaboration with the government sector, universities and local manufacturers to the bottleneck problems.

In general, under economic crisis, mechanization in Thailand is still advancing. More powerful and sophisticated machinery such as tractors, seed drills, transplanters, power sprayers, harvesters and dryers are needed by farmers to improve farming performance. However, research and development have mainly focussed on post-harvest technology.

Agricultural Machinery Manufacturing Status

The agricultural machinery industry of Thailand was established in 1965 with the production of low-lift propeller water pump and single axle 2-wheel tractor followed by various types of machines, including small rice milling machines, corn sheller and paddy thresher. This industry expanded rapidly during 1970-80. At present local manufacturers can produce a wide range of agricultural machinery and implement. Some large manufacturers are producing control intensive machines which include paddy combine harvesters, mechanical dryers and sprayers. The distribution of selected important machines is shown in **Table 8**.

At present there are around 200 agricultural machinery manufacturers in Thailand. These firms vary in size and business, ranging from small workshop with working area of about 50 square meters each employing 4 to 5 workers to large manufacturers with working area of more than 3,000 square meters and employing more than 100 workers.

From the survey carried out by the Agricultural Engineering Research Institute (AERI) and the Thailand Institute of Science and Technology Research in 1987 and updated in 1994 by AERI, the manufacturers have been grouped into the following three categories with reference to the number of workers employed:

i) Small - up to 10 employees
- 94 manufacturers or 46%.

ii) Medium- more than 10 and up to 30 employees
- 72 manufacturers or 34%.

iii) Large - more than 30 employees
- 40 manufacturers or 20%.

Most manufacturers employ unskilled workers, having only primary school education. Generally, most firms train their own workers through experience and skills from the elder workers. With a few exceptions, some progressive manufacturers provide opportunity to their workers to attend some training courses organized by government agencies. There are about 30 percent of skilled workers or technicians. Recently a few manufacturers employed professional engineers. Some firms employ consulting work from private engineering companies. Normally, most of the small and medium size firms produce more than one type of machine but most of the large firms produce only one or two types. Most large and medium firms are located in the central plain region. Recently some of them have established branches in the other regions. Most firms have equipment such as lathes, shapers, drills, power saws, electrical or gas welders, guillotines, small rollers and air compressors. In addition, some of the large firms, especially single axle 2-wheel tractor factories have large hydraulic press, universal cutting machines and milling machines. Some even have sophisticated machine tools such as computer numerical controlled machines and computer-aided design facilities. Basic facilities such as foundry, gear cutting, forging and

Fig. 7 Powertiller in action.

Fig. 8 Rice thresher at work.

Fig. 9 Multipurpose axial flow thresher mounted on local-made small truck.

Fig. 10 Rice combine harvester in operation.

Fig. 11 Corn seeder on display.

Fig. 12 Dryer demonstration.

Fig. 13 Farm trailer astransport for produce.

Fig. 14 Corn harvester doing the job.

heat treatment are normally obtained from other specialized firms. Materials mainly used are mild steel, cast iron, and cast aluminum. General raw materials and simple services are available in their corresponding regions. However, most raw materials and services come from Bangkok or nearby provinces. This is one of the reasons why most firms are located around Bangkok. Engines are mostly local products from three joint venture companies. These firms have started producing diesel engines for domestic market since the beginning of 1980. The present annual production is around 120,000 units with about 80 percent for local contents.

The types of machines being produced locally with a few exceptions have been mostly developed by modification from imported prototypes or from public R&D institutes. The Agricultural Engineering Research Institute has contributed a great deal in the development of new prototypes for local manufacturers. There are also a number of newly developed prototypes in the pipeline for first commercial production.

Although it is quite obvious that more sophisticated machineries will be urgently needed by most farmers in the progressive farming areas. Nevertheless, it will take quite a long time to develop and manufacture these types of machines without any cooperation from the other countries which had already developed these machines. Most agricultural machines are not universal. Machines developed in one country may not be suitable in other countries. Thus, it is very risky to import or manufacture any agricultural machines and components before having them tested in local conditions. Therefore, it requires a lot of efforts and investments for the establishment of joint venture for agricultural machinery manufacture. This creates difficulty for private manufacturers to form this type of cooperation by themselves. It might be necessary for the public sector to initiate and assist the establishment of cooperation and transfer to private manufacturers when machines are suitable and have high marketing potential.

Since the economic crisis in Thailand during 1996-01, as discussed with local manufactures, agricultural machinery production was reduced to 50%. The large manufacturers which produce vehicle parts faced problems on dwindling orders. Small four-wheel tractors and small combine harvesters are being developed by this manufacturer in coorporation with a university. Some locally-made agricultural machines are shown in **Figs. 7 to 14.**

Promotion of Agricultural Machinery

The promotion of agricultural machinery activity in Thailand is mostly carried out by the public sector with a few exceptions. Some large manufacturers/dealers might arrange demonstration of their new products and also by means of credit in kind provided by The Bank of Agriculture and Agricultural Cooperatives (BAAC). However, the main agencies responsible for this activity are AERI and the Farm Mechanization Sub-Division, Department of Agricultural Extension (DOAE). In the past, the promotion of farm mechanization was long neglected in the extension program of DOAE. To some extent this negligence retarded the mechanization and the agricultural production development in the country. In 1979, the Farm Mechanization Sub-Division was established in the DOAE to fill in the gap on agricultural production technology.

At the start, the related technology cannot easily be transferred to the farmers through the existing Training and Visiting (T&V) System, due to a lack of Subject Matter Specialist (SMS) in farm mechanization at the provincial level. Thus in 1981, the DOAE started to establish Farm Mechanization Promotion Centers in order to support the Agricultural Mechanization Promotion Program at provincial level. At present, there are four DOAE Farm Mechanization Promotion Centers: Chainat in the central plain region, Petchaburi in the west, Roiet in the northeast, and Chiang Rai in the north. Since then, extension of agricultural machinery activity seems to improve.

In case of AERI, the promotion of newly developed machines in the past was ineffectively undertaken without explicit work plan and target. The Division tried to promote mechanization on a dispersed nationwide basis that resulted in unsatisfactory results. In 1984, under the UNDP/FAO/THA Agricultural Machinery Production Project, AERI changed its extension strategies from nationwide basis to only selected or pilot areas. However, at present, five DOA Agricultural Engineering Operating Centers are functioning strengthened are able to undertake not only training activities but also to conduct testing, evaluation and demonstration of newly developed machines at the regional level. Accordingly, more of the extension resources among which are staff, machines, training facilities, workshops, etc. were allocated to these centers, namely; Pathumthani (Central Plain), Nakornsawan (Lower North), Chiengmai (Upper North), Khon Kaen (Northeast), and Pattulung (South).

In the case of industrial extension, the AEI staff frequently visit some manufacturers to gather and exchange information. It has an annual budget for providing technical assistance to at least 5 manufacturers every year.

The present bottleneck of agricultural mechanization extension activities is the lack of sufficient competent extension officers at provincial and district levels. The DAE has realized this main shortcoming and had conducted several training courses for extension officers. However, most provincial and district level officers are mostly agricultural technologies graduate. Therefore, it is quite difficult to train them to be able to carry out mechanization extension activities efficiently. Notwithstanding this constraint, a more intensive training program for extension officers has been formulated by AERI and DOAE and will be submitted for approval and implemented during the Eighth National Plan.

Standardization

The standardization of agricultural machines has been established in power-tiller, thresher, rice mill and combine harvester. The existing role in standardization emphasized standard parts of power-tiller in order to reduce the cost of manufacturing and spare parts. The standard parts of transmission system (gearbox) has been developed to be used by local manufacturers.

Organizations Involved in Farm Mechanization

Organizations involved in farm mechanization in Thailand are mainly the government service: AERI, Department of Agriculture, Ministry of Agriculture and Cooperatives. Thai Society of Agricultural Engineering (TSAE) and some non-governmental organizations.

Thai Association of Agricultural Engineering (TSAE)

The TSAE was established in 1975 whose activities were limited in 1989 to 1994. In 1995 it was reactivated by the new committees and continued to function to the present time. At present, 169 members of them are lecturers, researchers from universities, government officials, private sectors and farmers.

The goal of TSAE is to promote cooperation among the staff in the Agricultural Engineering field. Annual National Seminars have been continuously conducted in 2000 in Bangkok (hosted by TSAE), 2001 in Khon Kaen (hosted by Khon Kaen University) and 2002 in Chiang Mai (hosted by Mae Joe University) and 2003 in Bangkok (hosted by Kasetsart University).

A handbook for Buy-Sell Agricultural Machinery was published biannually in 1999 and 2001 that serves as a guideline for farmers in purchasing agricultural machinery.

Some technical seminars and training courses for local manufacturers are also conducted with the support from JODC (Japan Overseas Development Cooperation) and the Ministry of Science, Technology and Environment.

Conclusion

During this period of economic crisis, farm mechanization still has important role in improving agricultural production. The research and development efforts aim to undertake the following activities:

1. Collaboration among researchers from government sectors, educational institutes and manufacturers is the important aspect to ensure that the research works will be continuously implemented.
2. The cost reduction in manufacturing by using standard parts among different manufacturers will be benefit not only the cost reduction for manufacturers but also more convenient for farmers to buy spare parts. Power tiller standard parts (gearbox) project is the example of a successful project which is supported by the Thai Research Fund (TRF) and has a collaboration among AERI and 13 local manufacturers.
3. Value-added production by improving machinery for post-harvest technology and processing is pursued.
4. Researches under government fund are grouped into projects. Each project must be evaluated by the National Research Council. In the past, research proposals were evaluated by each organization.

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(Continued from page 36)

Manual Sugarcane Harvesting System vs. Mechanical Harvesting System in Thailand

Fig. 12 Manual harvesting systems deliver clean cane to the mill plant which benefit the cane industry with high sugar extraction efficiency and high sugar quality.

Fig. 13 Trash problem in harvested cane from chopper harvesters.

Fig. 14 Mechanical damage on the canes' roots can severely affect germination, which poses a potential threat to the yield in the following season.

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Studies on Murrah He-buffaloes Using Improved Rotary Appratus

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Abstract

Draft animals play a key role as farm power source in India, more so in hill agricultural where topography, terrace size and shape limit the use of tractors and other farm equipment due to restricted accessibility, and reduced field efficiency among others. For better economy, these animals should be used for about 2500 hours annually. However, in hill agriculture their annual utilization varies from 300-1500 hours only. As such, in order to enhance their utilization, these animals in idle period can be used in rotary mode for undertaking stationery work for which traditional bull gear unit is used. The bull gear unit has the disadvantage of low transmission efficiency and frequent breakdown with excessive wear and tear. To increase the efficiency and reliability of the transmission unit of a rotary mode, a gearbox unit designed and developed at Pantnagar (Sharma et al., 1996) using available gears in the market, was used to assess its potential to enhance the draft capacity of Murrah he-buffaloes in two work rest cycles on sustainable basis. The study shows the over all efficiency of the transmission unit was 84.10%, the Murrah he-buffaloes worked for 4 to 8 hrs depending on work rest cycles and drafts. There were 320 to 806, 61.36% to 92.68% and 5.43% to 11.32% increase in RR, PR and RT, respectively. The power output was maximum (6.46 hp-hr) for C_2 cycle at a draft equivalent to 12% body weight and as per FSC, the performance of C_2 work rest cycle was better than C_1 work rest cycle.

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Introduction

About 73 million head of bullocks and 8 million head of male buffaloes in India are capable of providing 32,000 M watts of power. It is estimated that complete replacement of draft animals, implements and carts by tractor system will require an investment of approx. Rs. 1,60,000.00 crores with an annual fuel consumption of Rs. 22,000.00 crores. In a developing country like India this type of replacement is not possible in the near future (Srivastava, 1995). Further, the annual utilization is very low, i.e., between 300 and 1500 hours against the total use of 2500 hours for better economy.

To enhance their annual utilization, the animals can be used in a rotary mode of operation for operating a loop type paddy thresher, groundnut decorticator, maize sheller, electric generator among others. The traditional bull gear being used has the disadvantages of a low transmission efficiency and frequent wear and tear. As such, the present study was carried out the draft capacity of Murrah he-buffaloes in a rotary mode of operation using improved rotary apparatus designed and developed at GBPUA and T Pantnagar (Sharma et al., 1996).

Materials and Methods

The experiments were conducted on a test track using a new transmission unit with a speed of up to a ratio of 1:117 (**Fig.1**). The animals were loaded using a hydraulic system of CIAE loading car through the newly developed mechanical gear unit. The load on animals in terms of draught force was measured using hydraulic dynamometer mounted on the beam at a distance of 3.3m from the center of rotation of the unit (**Fig.2**). The hitching of animals with the rotary apparatus was attained through a beam and a local yoke. The experimental setup is shown in **Fig.1**.

Fig. 1 Experimental setup for measuring draughtability of He-buffaloes in rotary mode of operation.

Fig. 2 Dynamometer attachment for draught measurement.

Fig. 3 Recording of physiological responses for assessing fatigue in he-buffaloes.

Two Murrah he-buffaloes used for the experimental studies were trained by a skilled operator for one week to accustom them with the pattern of experiment.

The draft loads of 110, 132 and 154 kg. (i.e., equivalent to 10, 12 and 14% of body weight of the Murrah he-buffaloes) were applied for two work rest cycles, namely; C_1 = 2h(w)-1/2h (R) -2h(w)-1/2 (R)-2h(W)-1/2 h(R)-2h(w); and C_2 = 4h(w)-7h (R) –4h(w). The physiological responses like respiration rate (RR), pulse rate (PR), rectal temperature (RT) (**Fig. 3**) and distress symptoms like frothing, uncoordinated leg movements, excitement, unaware of proper movements and tongue protrusion (**Fig. 4**). All these were recorded for two work rest cycles and three drafts, hourly for 4 to 8 hrs of operation depending upon the period, animals' work efficiency. The average speed was calculated and each treatment was replicated thrice between April 2, 1996 to June 28, 1996. A fatigue score card (FSC) based on the Upadhay and Madan concept (1985) was prepared as per the recorded responses in each treatment. All the experiments at different loads and cycles were conducted from 5 a.m. onwards.

The mechanical efficiency of the complete transmission unit was determined by calculating the power available at the output shaft and the power input at the input shaft. The power output was determined by finding the speed of output shaft and torque with the help of a prony brake type dynamometer. The input power was calculated by recording the draft and speed of travel of the he-buffaloes.

Result and Discussion

The comparative performance of the Murrah he-buffaloes under a rotary mode of operation in two work-rest cycles and three drafts were evaluated for determining the work efficiency without undue fatigue. The average ambient temperature, relative humidity, wind velocity and solar radiation were 22.1 to 43.0°C, 20 to 81%, 0.2 to 10.4 kmph and 463.62 to 5.6.8 cal cm^{-2}, day^{-1}, respectively during the entire period of investigation.

Fig. 4 Recording of distress symptoms for assessing fatigue in he-buffaloes.

Variation in Respiration Rate

The data shows substantial increase in RR from its preceding values with the duration of work, the increase being high at higher draughts. The increase in RR from resting value for C_1 cycles were 494, 806 and 784% for drafts equivalent to 10, 12 and 14% after a work period of 8,7, and 4 h, respectively (**Table 1**). The increase in the RR of the outer

Table 1. Respiration Rate (Blows/ Min) of Test Buffaloes at Three Draughts and Two Work Rest Cycles in Rotary Mode of Operation

Cycle	Draught (%)		Period of work- Rest (hrs)											
			IN 0	W 1	W 2	R	W 3	W 4	R	W 5	W 6	R	W 7	W 8
C_1	10	G. Average	18	39	51	28	39	53	48	65	86	76	93	107
		P.I.	--	116.7	46.2	--	39.3	35.9	--	35.4	32.3	--	22.4	15.1
	12	G. Average	18	46	96	68	98	127	106	134	168	132	163	♦
		P.I.	--	155.6	108.7	--	44.12	29.59	--	26.11	25.37	--	23.48	♦
	14	G. Average	19	50	96	74	128	168	--	♦	♦	--	♦	♦
		P.I.	--	163.20	92	--	73	31.3	--	♦	♦	--	♦	♦
C_2	10	10 G. Average	20	38	62	--	78	96	27	60	68	--	76	34
		P.I.	--	90	63.1	--	25.8	23.1	--	122.20	13.3	--	11.8	10.6
	12	12 G. Average	20	44	90	40	118	130	36	64	98	--	120	129
		P.I.	--	120	104.5	--	31.1	10.2	--	77.8	53.1	--	22.1	7.5
	14	14 G. Average	20	50	96	--	152	178	36	80	159	--	♦	♦
		P.I.	--	150	92	--	58.3	17.1	--	122.2	98.8	--	♦	♦

C_1 = 2h(w)-1/2h (R) -2h(w)-1/2 (R)-2h(W)-1/2 h(R)-2h(w); C_2 = 4h(w)-7h (R) –4h(w);
W = Work Period, R = Rest Pause;
IN = Initial, G. Average = Grand average of three replications;
P.I. = Percentage increase from preceding value, ♦= Buffaloes did not work due to fatigue;
Draught ♦♦ = Draught equivalent to % of body weight.

Table 2. Pulse Rate (Beats/ Minutes) of Test Buffaloes at Three Draughts and Two Work Rest Cycles in Rotary Mode of Operation

Cycle	Draught ♦♦ (%)		Period of work- Rest (hrs) IN 0	W 1	W 2	R	W 3	W 4	R	W 5	W 6	R	W 7	W 8
C1	10	G. Average	44	52	60	48	55	62	56	63	68	62	67	71
		P.I.	--	18.18	15.38	--	14.58	12.7	--	12.5	7.94	--	8.06	5.97
	12	G. Average	41	52	64	53	62	69	64	70	76	73	79	♦
		P.I.	--	26.8	23.47	--	16.98	11.29	--	9.37	8.57	--	8.22	♦
	14	G. Average	40	53	68	54	67	77	--	♦	♦	--	♦	♦
		P.I.	--	32.5	28.3	--	24.1	14.9	--	♦	♦	--	♦	♦
C2	10	G. Average	42	53	59	--	64	69	44	59	71	--	68	67
		P.I.	--	26.2	11.3	--	8.47	7.81	--	34.1	20.3	--	-1.23	-1.47
	12	G. Average	43	57	64	--	70	76	45	59	67	--	71	70
		P.I.	--	32.6	12.28	--	9.38	8.57	--	31.11	13.6	--	5.97	-1.41
	14	G. Average	44	57	65	--	74	81	50	71	83	--	♦	♦
		P.I.	--	29.54	14.0	--	13.85	9.46	--	42	16.9	--	♦	♦

same note in **Table 1**.

buffaloes were 17.91, 17.19 and 19.89% higher than the inner buffaloes at draft loads of 10, 12 and 14%, respectively. This was mainly due to 1.47 times increase in travel distance of the outer buffaloes compared to the inner ones. This is in agreement with Thakur et al., (1987).

In the C_2 cycle, there were 320, 545 and 695% increase in RR over resting value at 10,12 and 14% draft after 8,7 and 4 h of work, respectively. The percentage increased in RR the over resting value during the pre-rest session were 380, 550 and 790. During the post-rest session, these figures were 211, 258 and 342 for the above mentioned drafts. The lower values in percentage increase of RR during the post-rest session as compared to the pre-rest session could be attributed to lower ambient temperature and cooler environment during post-rest session.

The comparative study of cycles and draft indicated that the percentage increase in RR was minimum at 320 (C_2-cycle; 10% draft; 8 h work) followed by 494 (C_1-cycle 10% draft; 8h work), 545 (C_2-cycle, 12% draft; 8h work), 695 (C_2-cycle; 14% draft, 6h work), 700 (C_1-cycle; 14% draft; 4h work) and 806 (C_1 cycle; 12% draft; 7h work).

Variation in Pulse Rate

In general, the PR of the buffaloes increased with the duration of work and decreased with the rest pause. The initial first hours of work showed an increase of 13.63 to 32.50% in PR over the resting value whereas the increase over the preceding value during the second hour of work was 10.0 to 28.3% for two cycles and three drafts (**Table 2**). The data further indicated that after the first two hours of work, the increase in PR over the preceding value was at a decreasing rate that confirmed a steady state with respect to PR after 2 hrs of work.

The percentage increase in PR from the resting level for $_{C1}$ cycle were 61.36, 92.68 and 92.5 for 10, 12 and 14% draft after 8,7 and 4 h of work, respectively. Similarly, for the $_{C2}$ cycle there were 61.4, 63.2 and 88.4% increased in PR over the resting level for 10%, 12% and 14% draft after 8,8 and 6h of work, respectively. Like the RR, and PR of the outer buffaloes were also more pronounced than the inner buffaloes.

Variation in Rectal Temperature

The percentage increase in RT over the resting value were 7.82, 10.80 and 10.7 for C_1 cycle at a draft load of 10, 12, 14% of body weight after 8,7 and 4 h of work, respectively (**Table 3**). This increase in the case of the outer buffaloes were 6.45, 11.50 and 12.6% and in the case of the inner buffaloes, which were 5.45, 9.73 and 9.41% for above mentioned draft and work periods, respectively.

In the C_2 cycle, there were 5.43, 5.66 and 12.32% increases in RT over resting value after 8, 8 and 6 h of work at drafts equivalent to 10, 12 and 14% of body weight, respectively. It is clear from the data that there was no appreciable increase in RT, in comparison to RR and PR.

Variation in Fatigue Score

The combination of draft, speed and work duration causes fatigue to animals. A fatigue score card (FSC) based on Upadhyay and Madan (1985) concept was prepared and presented in **Table 4** for the Murrah he-buffaloes. As per the FSC, the buffaloes showed some discomfort during the 8^{th} hour of work at 10% draft in C_1 cycle but they worked without any fatigue signs in the C_2 cycle. A draft load of 14% proved strenuous to the buffaloes, increasing the fatigue score for both the cycles. In general, the C_2 cycle showed a better performance as compared to C_1 cycle, due to its longer rest pause and less environmental stress during the evening hours.

Variation in Speed and Power Output

In general, there was a marginal increase in speed and power output during first two hours of work. Thereafter, the speed and power output decreased (**Table 5**). The decrease in speed and power output was greater at higher drafts compared to lower one. The maximum power (6.06 hr) was produced in C_2 cycle at 12% draught whereas the minimum (3.44 hp-hr) was produced for C_1 cycle at 14% draft.

Table 3. Rectal Temperature (Degree Celsius) of Test Buffaloes at Three Draughts and Two Work Rest Cycles in Rotary Mode of Operation

Cycle	Draught ♦♦ (%)		Period of work- Rest (hrs) IN 0	W 1	W 2	R	W 3	W 4	R	W 5	W 6	R	W 7	W 8
C1	10	G Average	37.1	37.70	38.40	37.90	38.6	39.20	38.80	39.30	39.70	39.5	39.80	40.00
		P.I.	--	1.62	1.86	--	1.85	1.55	--	1.29	1.02	--	0.76	0.50
	12	G. Average	37.1	38.10	39.00	38.50	39.3	40.00	39.40	40.10	40.70	40.4	41.00	♦
		P.I.	--	2.70	2.36	--	2.08	1.78	--	1.77	1.51	--	1.48	♦
	14	G. Average	37.3	38.70	39.80	39.10	40.10	41.30	--	♦	♦	--	♦	♦
		P.I.	--	3.75	2.84	--	2.81	2.74	--	♦	♦	--	♦	♦
C2	10	G. Average	36.8	37.90	38.60	--	38.90	39.20	37.40	38.20	38.90	--	38.80	38.80
		P.I.	--	2.99	1.85	--	0.78	0.77	--	2.14	1.83	--	-0.26	0.00
	12	G. Average	37.1	37.80	39.60	--	39.3	39.90	37.40	38.30	38.90	--	38.60	39.20
		P.I.	--	1.89	2.12	--	1.81	1.53	--	2.41	1.57	--	-0.77	1.55
	14	G. Average	37.1	38.20	39.20	--	39.9	40.60	37.80	39.20	41.30	--	♦	♦
		P.I.	--	2.96	2.61	--	1.79	1.75	--	3.70	2.81	--	♦	♦

same note in **Table 1**.

The average hp/hr and speeds were 0.73 to 0.87 and 0.42 to 0.52 m/s for all treatments.

Mechanical Efficiency

The mechanical efficiency of the system was 84.10%.

Table 4. Average Fatigue Score Card of Test Buffaloes in Rotary Mode of Operation During Two Work-rest Cycles and Three Draughts

Cycle	Draught ♦♦ (%)	Hour of Effective Work (hrs) 1	2	3	4	5	6	7	8
		(Average fatigue score card)							
C1	10 %	4	8	12	14	17	18	20*	21*
	12 %	8	11	13	16	18	20*	23*	♦
	14 %	9	15	19	25*	♦	♦	♦	♦
C2	10 %	4	9	16	21*	10	14	18	20*
	12 %	8	11	18	22*	12	16	17	22*
	14 %	9	16	21*	28*	18	26*	♦	♦

*Buffaloes were declared fatigued when score points reach 20 or more.
♦ Buffaloes did not work due to fatigued during this hour.
Draught ♦♦ = Draught equivalent to % of body weight.

Table 5. The Average Speed and Power Produced During C1 and C2 Work Rest Cycles at Different Draughts

Parameter	Cycle	Draught ♦♦ (%)	Hours of work IN	1	2	3	4	5	6	7	8
Speed (m/s)	C1	10	0.52	0.56	0.56	0.55	0.52	0.49	0.47	0.44	0.41
		12	0.49	0.52	0.51	0.47	0.45	0.44	0.41	0.36	♦
		14	0.43	0.46	0.44	0.42	0.36	♦	♦	♦	♦
	C2	10	0.59	0.60	0.60	0.59	0.51	0.56	0.55	0.53	0.51
		12	0.50	0.52	0.50	0.46	0.41	0.50	0.46	0.44	0.38
		14	0.47	0.50	0.49	0.44	0.38	0.49	0.42	♦	♦
Power (hp)	C1	10	0.76	0.82	0.82	0.81	0.76	0.72	0.69	0.65	0.60
		12	0.86	0.92	0.90	0.83	0.80	0.77	0.72	0.63	♦
		14	0.88	0.94	0.90	0.86	0.74	♦	♦	♦	♦
	C2	10	0.87	0.89	0.89	0.86	0.75	0.82	0.81	0.77	0.75
		12	0.88	0.92	0.88	0.81	0.72	0.88	0.81	0.77	0.67
		14	0.97	1.04	1.00	0.91	0.77	1.02	0.86	♦	♦

♦ Buffaloes did not work due to fatigue.
Draught ♦♦ = Draught equivalent to % of body weight.

Conclusions

The mechanical efficiency of the complete transmission unit was 84.10%.

The Murrah he-buffaloes worked for 4 to 8 hours depending on work-rest cycle and draft.

There were 320 to 806, 61.36 to 92.68 and 5.43 to 11.32 % increased over the resting value of respiration rate, pulse rate and rectal temperature, respectively.

The power output was maximum (6.46hp-hr) for C_2 cycle at 12% draft.

The fatigue score card for the performance of C_2 work rest cycle [4h(w)-7h (R) –4h(w)] was better than C_1 work-rest cycle [2h(w)-1/2h (R) -2h(w)-1/2 (R)-2h(W)-1/2 h(R)-2h(w)].

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The Farm Machinery Industry in Japan and Research Activity

The Present State of Farm Machinery Industry

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Outlook of Agriculture

Trend of Agriculture

In 2000 agricultural total products was ¥5,135 billion, accounting for 1.0% of GNP. The agricultural products Imports decreased to $40.4 billion in 1996, $37.0 billion in 1997, $34.0 billion in 1998. It has kept changing around $36 billion since 1999.

The agricultural products exports was $2.3 billion in 1999. $1.6 billion in 1999, $2.5 billion in 2000. Japan depends on imports for large part of domestic consumption of feed cereals, soybean, wheat. Food self-sufficiency rate was 40% by calorie base in 2001, 28% for cereals, almost the same as preceding year.

Population mainly engaged in farming has been decreasing yet, 2.79 million in 2001, 4.4% of total working population. The number of Farm houses decreased to 3.07 million in 2001. 75% of them are commercial farms selling their products in market. Total arable land in Japan was 4.79 million ha in 2001. Average arable land per farm was only about 1.6ha.

Japanese have been getting to enjoy more a variety of food since 1970's. The production of rice, oranges, milk, eggs has exceeded domestic consumption. Under such circumstances, GATT New Round Agreement gave great impact to Japanese agriculture. In order to get world competitive power, saving of production cost became the urgent issue. Other big issues in Japanese agriculture are, to have enough people engaged in farm work to maintain stable agriculture, production of high quality and safe products to meet the needs of consumers, and preservation of natural environment in rural areas.

In July 1999, Japanese government enacted the New Agricultural Stable Law, which aims to assure constant food supply by raising domestic production, to encourage multi-functions of agriculture, to have sustainable development of agriculture and to promote the development of rural areas. The law makes it a target that 50% of national food consumption is covered by domestic production, at least to raise self-supply rate up to 45% by 2010. In 2000 Japanese government enacted guidelines for dietary patterns to improve national dietary, the Food Recycle Law to decrease food waste, the revised Japanese Agricultural Standards (JAS) Law to improve food safety. BSE incident in 2001, food display forgery incident and usage of non registered agricultural chemicals in 2002 made the government to take measures for food safety.

Trend of Farm Mechanization

Agricultural mechanization in Japan has made remarkable progress in the field of low land rice, chief crop, in a short period since 1955. Now rice production is almost mechanized from planting to harvesting. In 2002, average working hours on 10a paddy field reduced to 32.4 hours from 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be larger-sized, 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 to 1997, government carried out Urgent Development Project to intensify the development of high performance farm machines to raise farm productivity and reduce farm work burden. From 1998 to 2002, government carried out 2nd Urgent Development Project to develop new machines for 21st century which are useful in environmentally kind agriculture and useful for labor

Table 1. Major Farm Machinery on Farm — Unit: Thousand

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer & 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	2,318	1,869	1,921	1,022	1,203	1,121
2000	1,048	2,028	1,433	1,269	583	1,042	861

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

Table 2. Shipment 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
1992	199,141	88,754	80,105	184,016	105,028	20,888	60,941	52,275
1994	172,471	88,501	82,210	162,422	98,266	22,589	60,741	57,070
1996	173,894	93,660	73,204	165,467	99,342	18,476	60,198	59,546
1997	174,004	87,416	64,859	177,064	90,133	16,770	53,095	52,389
1999	180,511	72,533	59,529	166,380	54,717	12,010	40,822	39,416
2000	169,996	72,554	55,386	163,904	52,540	10,648	40.888	33,483
2001	145,557	85,933	47,285	156,598	44,845	8,019	35,685	29,782
2002	142,774	64,781	48,054	151,860	42,239	6,991	34,397	29,148

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

saving in mountains area. Under these projects, 34 types of high performance machines were developed. They are, a large all-purpose combine, a full automatic vegetable transplanters, riding-type vegetable cultivator, and a Japanese leek harvesting machine. To spread these developed machines, government set up standard cropping system for 11 kinds of vegetables and so on.

From 1995 to 2002, local governments developed machines which are appropriate for the production of special local products. Research and development were done for 45 issues and all were finished. Machines for onion, sweet potato and soybean were put in practical use.

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. Low cost machinery with limited functions has been increasing.

Following are the numbers of farm machines in possession of commercial farm household as of Feb.1,2000: riding tractor 2,028,000 units ; walking tractor 1,048,000; rice transplanter 1,433,000; head feed combine 1,042,000(**Table 1**).

Shipments of major farm machinery in domestic market in 2001 are as follows : riding tractor 64,781 units (under 20PS were 17,063; 20-30PS 29,247; 30-50PS 12,057; over 50PS 6,419); walking tractor 142,774; rice transplanter 48,054; combine 34,397 (standard types were 1,082); grain dryer 29,148; huller 24,502. The shipment of safety cabins and safety frames attached to tractors rose sharply to 64,394 units(**Table 2**).

Recently more and more used farm machines are distributed. The rate of used farm machinery in 1998 in the total sales amount is : riding tractors 39%; rice transplanter 32%; combine 39%.

Plans for Farm Mechanization

The NatIonal budget for agriculture, forestry and fishery for 2003 amounted to \3,111.4 billion, decreased by 2.5% compared with the preceding year.

The important policies are;

To reduce agricultural material cost

To raise contractors who are to support farm management in extending the scale of production.

To develop next generation agricultural machines in urgent need.

Movement of Farm Machinery Industry

There are two kinds of Japanese farmers. One is professional large scale farmers and the other is hobby small farmers. We can find this tendency in the shipment of agricultural machineries. Large and small machines shipment are not bad. But middle size machineries are not good.

There is a clear tendency that small farmers seek cheaper machines. Many makers have already manufactured cheap type machines. Because of aging problem in rural area, concentration of farmland is ongoing. Large farms are extending their farmland more and more. Agricultural machinery makers are trying to meet farmers' demand in this diversity.

Many of agricultural machines are domestic until now, and the import machine was restricted on a large scale. However, it is expected that cheap import machines increase in number so that it may be represented by the South Korean product after this. The wave of globalization is rolling in also to the agricultural machine industry.

Meanwhile consumers concern for food safety is increasing and food traceability became a key to assure food safety. Here a new role is being expected to agricultural machines. How to meet this demand is the important issue in the future.

Trend of Farm Machinery Production

Farm machinery production in 2002 amounted to ¥440.9 billion (0.5% increase over the preceding year) by the Ministry of Economy, Trade and Industry production dynamic statistics.

Production of the major farm machinery is as follows: Riding tractor 149,202 units increased by 10.2% over the preceding year. By H.P., those under 20PS amounted to 50,743 units, 20-30PS 40,239 units, over 30PS 58,220 units(increased sharply over previous year).

The production of walking tractor amounted to 174,683 units, which showed a decrease of 9.0% under the preceding year. Under 5PS was 111,697 units, over 5PS was 62,986 units.

The production of combine, which is next to the riding tractor in production amount, is 35,658 units (a decrease of 1.4% under the preceding year). The most popular type is with harvesting width of one

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
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	—	615,974	160,518	219,446	225,229	31,803	63,367	53,236	172,034	7,776	110,736	5,278	7,799	10,223
1998	—	491,973	144,774	194,954	212,551	29,669	53,122	46,218	156,890	7,256	86,535	4,086	7,973	9,204
1999	—	539,960	156,452	220,047	253,817	36,365	58,137	43,146	153,118	7,416	77,693	3,567	7,194	9,282
2000	—	520,956	163,536	204,339	243,995	31,647	56,784	44,887	162,527	7,763	82,832	3,607	6,000	9,896
2001	—	453,946	135,353	170,063	191,941	25,372	50,918	41,887	139,360	6,036	70,422	2,679	6,465	9,854
2002	—	456,024	149,202	184,843	174,683	22,172	47,911	40,696					4,907	7,691
(2003)		237,302	78,678	97,630	81,069	9,777	28,979	25,366					3,041	4,833

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	60,006	18,332	59,269	39,990	58,500	4,871
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	27,339	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	44,451	6,096
1997	15,027	4,283	948,178	21,071	9,042	3,542	56,709	152,627	56,887	21,434	56,647	46,529	42,391	5,148
1998	8,631	2,336	1,012,372	22,236	5,102	1,988	40,196	103,435	28,113	10,705	32,968	26,543	39,729	3,588
1999	11,816	3,436	1,084,889	24,172	5,508	2,228	42,173	112,145	37,579	14,491	36,920	29,976	36,342	2,464
2000	11,291	3,104	1,011,889	23,132	5,586	2,106	41,137	100,671	26,089	9,784	35,780	29,227	39,235	7,667
2001	8,172	2,274	963,965	20,200	4,421	1,589	36,158	91,210	23,973	9,209	31,567	26,007	36,427	6,972
2002	6,779	1,853	952,8985	19,715	3,211	1,357	35,658	94,608	21,630	8,347	32,160	25,697	25,006	3,482
(2003)	2,656	684	70,001	12,102	1,791	769	18,169	42,424	13,434	5,781	15,070	13,021	15,044	1,829

Source: "Survey of Status of Machinery Production" by the Ministry of International Trade and Industry. Data by Japan Agr. Machinery Manufactures' Assn. and Land Internal Combustion Engine Manufacturer's Assn.

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 m^2	Annual sales value (2)/(1)
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5
1991.6	9,480	45,705	1,158,924	170,104	984,700	122.2
1994.6	8,838	43,112	1,128,087	166,298	978,788	127.6
1997.6	8,820	45,090	1,265,902	170,350	901,851	143.5
2002.6	8,123	40,441	979,066	145,725	982,529	120.5

Source: Ministry of International Trade and Industry.

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (2000 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
1992	3,204	354,728	268,393	388,031
1994	2,669	378,660	281,625	417,474
1996	2,331	374,334	279,070	415,691
1998	1,840	274,510	200,124	313,107
1999	1,620	274,361	197,069	309,739
2000	1,424	266,454	188,492	301,219
2001	1,182	259,213	182,993	294,234-

Source: "Statistics on Agricultural Cooperatives—2000 business year" by the Ministry of Agr., Forestry & Fisheries.

meter head feed.

Followings are the production of other types of farm machinery; rice transplanter amounted to 47,911 units (a decrease of 5.9% under the preceding year), grain dryer 32,160 units (an increase of 1.9%), huller 21.630 units (a decrease of 9.8%), bush cleaner 952,898 units (a decrease of 1.1%), power pest-controller 191,940 units (a decrease of 8.5%) so on (**Table 3**).

As for the machines other than mentioned above, according to the statistics by Farm Machinery Manufacturers' Association, binder (walking type cutter for rice and wheat) 6,779 units (a decrease of 17.0%), thresher 3,211 units (a decrease of 27.4%), cutter 30,725 units (a decrease of 15.2%), rice sorter 19.943 units (a decrease of 2.6%), farm transport vehicle 25.313 units (a decrease of 6.1%), output of 5 models is ¥15.1 billion, which shows a decrease of 8.8% compared with the preceding year.

Total production amount(putting ¥440.9 billion of the Ministry of Economy, Trade and Industry production dynamic statistics and ¥15.1 billion of 5 models together) is $456.0 billion, 0.5% up over the preceding year.

Trend of Farm Machinery Market

In Japan distribution systems for farm machinery is roughly divided into two major channels; the dealers concerned and Agricultural Cooperatives Association. As of June 2002, the retail shops were recorded to about 8,100, the employees amounted to 40,000 persons, and the annual sales amounted to ¥979

Table 6. Export of Farm Equipment 2001

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		
1997		130,351		
1998		143,843		
1999		149,066		
2000		139,049		
2001		126,173		U.S.A., France,
2002		148,581	100.0	Korea
Power tiller	53,861	3,337	2.2	France, U.S.A.
Wheel tractor	129,548	98,253	66.1	U.S.A
Seeder, Planter	3,217	2,237	1.5	Korea, Taiwan
Power sprayer	34,470	1,137	0.8	Korea, U.S.A, Taiwan
Duster	6,587	208	0.1	Korea
Lawn mower	33,591	3,849	2.6	France
Brush cutter	862,203	18,349	12.3	U.S.A, France
Mower	39,659	926	0.6	U.S.A., Korea
Combine	674	2,560	1.7	Taiwan, Korea, China, Peru
Chain saw	179,748	3,809	2.6	U.S.A., Italy, France
Others	—	13,916	9.5	

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

Table 7. Import of Farm Equipment 2001

Unit: CIF million yen

Year	Unit	Value	Ratio	Major exporters
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578		
1994		27,779		
1995		27,015		
1996		33,542		
1997		33,069		
1998		27,513		
1999		23,308		
2000		25,825		
2001		32,603		U.K., Germany,
2002		33,988	100.0	China
Wheel tractor	2,819	11,906	35.0	U.K., Italy, Germany
Pest control machine	3,838,874	1,928	5.7	China
Lawn mower	78,830	2,041	6.0	U.S.A., Sweden, Germany
Mower	3,230	1,566	4.6	France, Netherlands
Hay making machine	1,097	644	1.9	Germany, France
Bayler	843	1,697	5.0	U.S.A., Germany, France
Combine	83	1,087	3.2	Belgium, Germany
Chain saw	34,502	770	2.3	Germany, Sweden, U.S.A.
Others	—	12,349	36.3	

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

billion (**Table 4**).

According to the governmental survey by Ministry of Agriculture, Forestry, the total sales of farm machinery by Agricultural Cooperative Association reached ¥294.2 billion in 2001 (¥301.2 billion in 2000)(**Table 5**). The number of Agricultural Cooperative was about 1,182 in 2001. Average sales amount per cooperative increased to ¥250.00 million.

About half of private dealers are small firms with less than 5 employees. In a long time view with less demand for agricultural machines expected in future, improvement of management structure will be needed.

Export and Import of Farm Machinery

Export

In 2002 the export of farm machinery amounted to ¥148.6 billion, which showed an increase of 17.8% over the preceding year. The ratio of exports to the total production ¥456 billion was 32.6%.

By the export destination, ¥91.3 billion for North America (an increase of 23.3%), ¥22.2 billion for Asia(an increase of 16.9%), ¥25.8 billion for Europe(an increase of 5.7%). For North America, ¥85.4 billion was for U.S.A., tractor 76,918 units, ¥74 billion, which was a major part. Tractors for Asia is about 21,000 units, but maker's shipment is only 1,300 units, others are considered to be secondhanded machines (**Table 6**).

By the types of machines, tractor (consists main part of export); 129,548 units were exported in 2002 (the total production was 149,202 units). It amounted to ¥98.3 billion. Seeing by horse power, those under 30PS amounted to 83.524 units, those from 30 to 50PS 33.473 units, those over 50PS 12.551 units.

Major farm machine, next to tractor, is bush cleaner. The total exports were 862,203 units, ¥18.3 billion. The exports of other farm machinery are as follows; walking tractor 53.861 units ; power sprayer 34.470 units; lawn mower 33.591 units; grass mower 39.659 units ; chain saw 179.748 unit, etc.

Import

In 2002 the imports of farm machinery amounted to ¥34.0 billion, which means an increase of 4.2% over the preceding year.

Major imported farm machines: tractor 2,819 units (those more than 70PS were 2,258 units of all the tractor) ; chain saw 34,502 units, lawn mower 78.330 units, mower 13.549 units, fertilizer distributor 1,923 units. Tractors 1,105 units were imported from U.K. and about 638 units from Italy, 386 from German and 380 from France (**Table 7**). ■■

The Tokyo University of Agriculture and Technology in Brief

by
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Introduction

The title of this paper need not be misleading even as its main focus concerns only the agricultural machinery program and student s at the Faculty of Agriculture and not much of the Faculty of Technology . The twin campuses of the University are located in two different areas : the Faculty o f Agriculture at Fuchu and the Faculty of Technology at Koganei but both campuses are accessible by subway and surface trains for some 3 0-minute ride from Shinjuku- a central transportation hub in Tokyo.

The Tokyo University of Agriculture and Technology (TUAT) commenced operation in May 1949 as a national university under the new educational system that incorporated the then College of Agriculture and Forestry with that of the Tokyo Textile college.

Only after some four post-war years did the University opened its doors with a modest beginning utilizing three departments in Faculty of Agriculture. The Department of Veterinary Science opened later . On the other hand, the College of Technology had increased the number of departments to s ix by 1998. The TUAT has been improving its educational and research environment in order to correspond to the progress of contemporary science and the needs of society. In addition to the two faculties, graduate schools have already been introduced in various disciplines at both M. S. and Ph. D. degrees levels.

The Faculty of Agriculture

The education and research undertaking at the Faculty of Agriculture addresses the inherent problems in food production and resource management affecting the environment and health.

The Undergraduate Level

The basic and applied research in agriculture with its concomitant curriculum have a deiverse and wide range of specialization that cover not only the basic courses but also humanities and sociology. As a matter of fact, the Faculty currently has nine specialty areas related to the undergraduate courses and one independent specialty field in International Environment and Agricultural Science. But the most distinctive feature at the undergraduate level, particularly for students who are bent on considering the Faculty as a " finishing school, by those who cannot / do not pursue graduate programs, is the development among them an enterprising spirit, a keen perception of social needs in the country, a harmonized development o f analyses of problems and their solutions on the issues of food production, resources and environment.

The Master's Degree Level

As early as 1965, the Faculty o f Agriculture created six specialty fields of study. Each area of the graduate - degree level research corresponds quite exactly to a counterpart in the undergraduate - level system. This new plan enables the stablishment of a more flexible system to allow combinations of diverses specialty fields to further broaden education and research. Hence, the goal of the master's degree program is to produce specialists with a wide degree of analyticai skills and ability to apply them for the creation and development of new and profitable industries.

The Doctorate Degree Level

A recent innovation of the TUAT, in an effort the upgrade the status of the doctorate degree level, is the creation of an independent postgraduate school with a doctorate degree course of study for three years. This creation is identified as the United Graduate School of Agricultural Science (UGSA) which was a collaboration / cooperation among the chairs of post graduate master's degree courses o f the University o f Ibaraki, University of Utsunomiya and the Tokyo University of Agriculture and Technology. The intention is to compensate for any deficiencies in fields of study where a single university alone might lack the necessary depth and scope in a given master's degree subject.

It is for this reason that the UGSA carries out broad and high grade instruction and research. In order to complete these efforts, the UGSA offers general and specific seminars and issues occasional papers through which wide – ranging knowledge is available about what agriculture science research should be, ways of improving and stabilizing on livestock production, environment conservation, securing the safety of food products and development of biotic resources utilizing biotechnology.

The current enrollment at the doctorate degree level numbers 253 , including 93 foreign students but already the number of Ph. D. degree holders has reached 485, including 203 foreign graduates - considered a high accomplishment of the Tokyo University of Agriculture and Technology for both local and foreign Ph. D. graduates.

Agricultural Machinery

The discipline of Agricultural Machinery is composed of two major fields of education and research, namely ; the Agricultural and Environmental Systems Engineering and the Environmental Control. These fields of study were originally organized with the Department of Agricultural Engineering with three other fields, namely : Irrigation and Drainage, Agricultural Land Engineering and Agricultural Structure and Engineering until the year 1989. These fields of study have since combined as the Bio Production Engineering at the master's degree course.

The Department of Agricultural Engineering now belongs to the Environmental and Agricultural Engineering Division of the Department of Ecoregion Science.

Agricultural and Envir6nmental Engineering -

This field's teaching staff is represented by two professors : Dr. Akira Sasao and Dr. Sakae Shibusawa both on phytotehnology and an Associate professor, Dr. Kenshi Sakai, on Agricultural Eco-System. Their research topics at the present time are: Development of Man-machine System for Farm Products; Control of Vibratoin and Noise of Agricultural Machines; Mobile Fruit Grading Robot; Real-time Soil Spectrophometer and Precision Farming; Speaking Plant Approach to Environmental Contro; Field Parameter Spatial Mapping for SSCM (Infiltration Rate, pH, EC, and Weed Density; Application of Chaos Theory in Biologicai, Ecologicai and Agricultural Systems; Weed Seed Production Modeling to Optimize Weed Management; and Trafficability of Tractor - implement System.

Environmental Control

Two members of the teaching staff in this field of study at the present time are one Professor, Dr. Kengo Watanabe, and an Associate Professor, Dr. Seisyu Tojo, on Ecological Energy Use. Their research topics at this time are: The Effect of Storage Conditions Upon Rice Quality; Correlations Between Quality and Proportional Extent of Milling in Optical Images of Rice Stained Using NMG Method; Ecological Use of Renewable Energy; Refinery Technology for organic Wastes; and Organic Production System Recycling Organic Wastes.

International Exchange

Sister Universities

The University has a long history of international exchange Activities with foreign institutions of higher learning. At the present time, 46 sister universities have ties with TUAT in three categories as follows: one group of countries with Only one sister university each; another group with two sister universities; and a third group with more than two sister universities each : and a third group with more than two sister universities as follows:

Group I- Afghanistan, Australia, Czech Republic, Federal Republic of Brazil, Federal Republic of Germany, Kingdom of theNetherlands, Kingdom of Thailand, Republic of Ghana, Republic of Indonesia, Republic of the Philippines, Romania, Socialist Republic of Vietnam, and the United Nations.

Group II- French Republic, Republic of Poland, Kingdom of Sweden, and United Kingdom of Great Britain and N. Ireland.

Group III - People's Republic of China, 14; Republic of Korea, 4; and the U.S.A., 7.

Foreign Teachers and Researchers

The TUAT in May 1, 2003 had 25 foreign teachers 7 of which are identified as professors; 17 part-time foreign instructors and 2 full-time instructors; and 2 foreign researchers.

Foreign Students

About 10 years ago (May 1, 1991), 254 foreign students were enrolled in the University representing 25 countries. These figures rose to 404 and 37, respectively, on May 1, 2003. The latter count of 404 foreign students was distributed as follows:

People's Republic of China, 182; Republic of Korea,32; Socialist Republic of Vietnam, 2; Kingdom of Thailand,23; Republic of Indonesia, 21; Malaysia, 21 and all other countries with a total of 99.

In terms of financial background, 113 of them are recipients of scholarship grants from the Japanese Government. A break down of these foreign students, by enrollment on May 1, 3003, was: undergraduates, 5; master's degree, 57;

and doctorate degree,92. Ten foreign students and researchers are in the Agricultural Machinery program two of which are researchers from Bangladesh and the Philippines ; four in the doctorate program from China and the Domican Republic; two in the master's degree program from China and two more from China are researchers.

For further information, interested parties may communicate with TUAT at

http://www.tuat.ac.jp/index-e.html

Tbale 1. Department and Division of the Faculty of Agriculture.

Undergraduate Faculties		Graduate Schools			
		Master's Course		Doctoral Course	
Departments	Divisions	Divisions	Departments	Divsions	Departments
Biological Production	Applied Bioproduction Science	Science of Biological Production	Applied Bioproduction Science Analytical	Sience of plant and Animal Production	Plant Production Plant Protection Animal Production Management and Economics of Agriculture and Forestry Agricultural Engineering
	Analytical Bioproduction Science	Studies in Sustainable and Symbiotic Society	Bioproduction Science Agricultural Economics and Farm Management Humane and Social Studies of Man-Nature Relation	Biochemistry and Biotechnology	Applied Biological Chemistry Utilization of Biological Resources
	Agricultural Economics and Farm Management	Applied Biological Chemistry	Applied Molecular Biology and Biochemistry Biofunctional and Biomaterial	Science of Resources and Environment	Forest and Wood Science Environmental Science
		Bioregulation and Biointeraction	Applied Biology ang Biological Regulation		
		Natural Resources and Ecomaterials	Natural Resources and Materials		
		Environmental Science on Biosphere	Environmental Conservation		
		Enviroment Cinservation	Eco-design Forest Enviroment		
		Environmental and Agricultural Engineering	Environmental and Agricultural Engineering		

Farm Machinery Yearbook 2004

It includes the data about Farm Machinery Statistic of JAPAN

CONTENTS

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Higher Educational Programs of the University of Tsukuba

by
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Introduction

One of the major characteristics of the University of Tsukuba (UT) is to separate research and education. The university separates research institutes to which professors belong as researchers, from undergraduate and graduate schools in which professors are in charge as educators. Another major characteristic is to offer the graduate schools that in parallel consist of master's programs and doctoral programs. The former graduate programs are two-year master degree program for producing professionals with academic and technical expertise and providing re-educational opportunities for the general public. The latter graduate programs are five-year consecutive doctoral programs for producing independent researchers capable of conducting original research. General campus information regarding UT is available through following web site: http://www.tsukuba.ac.jp/.

Research Fields

The Institute of Agricultural and Forest Engineering is responsible to demonstrate the specialized research activities being relevant to their profession. This Institute consists of three different research fields including natural environmental engineering, farmland development engineering, and bioprocess and materials engineering. Various type of collaborative research funds and the Grant-in-Aid for Scientific Research from the Ministry of Education and Technology are steadily growing to endorse vigorous achievements.

Natural Environmental Engineering

i) Watershed Management
ii) Wildland Planning
iii)Forest Environmental Engineering
iv) Water Resources Engineering
v) Environmental Soil Physics
vi)Environmental Remote Sensing

Farmland Development Engineering

i) Colloidal Hydrodynamics
ii) Arid Land Engineering
iii)Bioproduction and Machinery

This academic discipline includes creative development in the field of bioproduction and machinery to enhance their quality and role in rural community. This area deals with optimum design of machinery, R & D of agricultural robot as well as electric tractor, compaction mechanism of agricultural soils, indigenous design concept of farming implements in Southeast Asia.

iv) Agricultural Structures and Environmental Control

Primary topics under investigation of this area include environmental control of closed bioproduction systems, salinization in greenhouse soils, planning method on rural landscape, numerical analysis for air-distribution in livestock housings.

Bio-process and Materials Engineering

i) Lignocellulose Engineering
ii) Biological Solid Wastes Engineering

This area covers specific topics including composting process for solid wastes derived from agriculture, food industries and municipalities, new materials developed from unutilized bioresources, rapid degradation technique for diodegradable plastics.

iii) Wood Chemistry
iv) Wood Machining
v) Food and Bioresource Process Engineering

Academic concerns of this area cover remediation of the water environment by enrichment of microbial functions, psychlophilic methane fermentation systems, endcrine problems in food chain, closed life support systems.

vi) Mechanical Engineering for Food Processing

This area focuses its professional interests regarding optimum design of feed formulation using genetic algorithm, sensory evaluation systems, growth prediction of creature body using neural network.

Faculty and Staff Member

(As of January 5, 2004)

Professor	12
Associate Professor	9
Assistant Professor	8
Research Associate	4
Technical Official	5
Adjunct Professor	5
Total	43

Education

The college clusters and schools are set up as the main systems for education at the undergraduate level. Each college cluster and school is based on a specialized field but is structured to cover a group of similar disciplines to promote further development from the educational point of view. The College of Agrobiological Resources is responsible to offer mainly agriculture-based curriculum, while the Graduate School of Life and Environmental Sciences provides solid, higher research and technical guidance in the consecutive five-year doctoral programs.

Undergraduate Curriculum

Selected course subjects for the degree of BS can be listed as follows:

- Principle of Agrobiological Resources
- History of the Development of Bioresource Sciences
- Practical Mathematics
- Structural Mechanics and Analysis
- Heat and Mass Transfer
- Soil Physics
- Fluid Engineering
- Experiments in Instrumentation
- Bioproduction Systems
- Bioproduction and Machinery
- Bioproduction Structures
- Systems Engineering in Bioproduction
- Agricultural Production Systems Laboratory
- Food Materials
- Postharvest Physiology and Technology
- Food Engineering
- Food Engineering Laboratory
- Food System Engineering
- Food System Engineering Laboratory
- Food processing Factory Design
- Mechanical Drawing
- Introduction to Mechatronics
- Bioproduction and Machinery/Structure Laboratory
- Practice in Metal Processing
- Bioproduction and Machinery Practice

Graduate Curriculum

The Ph.D degree requires the credits for specific subjects as listed below:

- Advanced Bioresource Technology
- Seminar in Bioresource Technology
- Research in Bioresource Technology
- Advanced Mechanical Engineering for Food Processing
- Seminar in Mechanical Engineering for Food Processing
- Research in mechanical Engineering for Food processing
- Advanced Food Process Engineering
- Seminar in Food process Engineering
- Research in Food process Engineering
- Plant-production Structures Engineering
- Advanced Bioproduction and Machinery
- Intelligent Systems for Bioproduction
- Seminar in Bioproduction and Machinery
- Research in Bioproduction and Machinery

Enrollment of Foreign Students

Roughly 1200 foreign students are currently enrolled to fulfill their academic programs in this campus. Those wishing further details regarding the college-cluster and graduate-school organization at the UT should consult the UT web site described earlier.

The standard admission criterion for undergraduate students is completion of 12 years of formal education in a country outside Japan. People with different academic backgrounds and those who wish to receive the application package for admission to the UT as self-supporting foreign undergraduate students should contact the Division of Admission.

For applicants wishing to enter the UT as graduate Students, the basic admission criterion is completion of 16 years of formal education in a country outside Japan. Students with different academic backgrounds are urged to contact the Division of Graduate Academic Affairs.

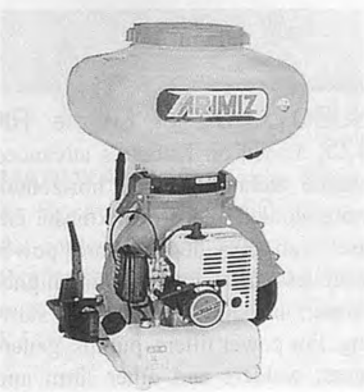
As for Japanese Government (*Monbukagakusho*) Scholarships, which are available in many countries for a wide rage of research fields, they have age limits of 35 years of age for graduate students and 22 years of age for undergraduate students. Therefore, please use your time in investigating the opportunities for scholarships. ■ ■

Main Production of Agricultural Machinery Manufactures in Japan

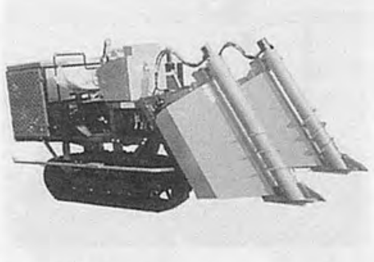
by
Shin-Norinsha Co., Ltd.
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101-0054 Japan

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

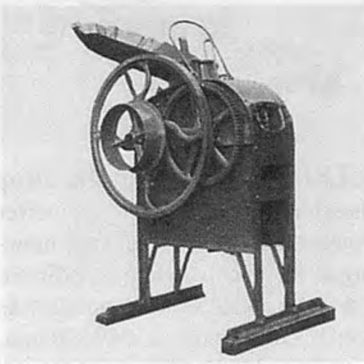
The products are developed and improved for both foreign and domestic markers. For further information please refer to the manufactures contained in the directory.



ARIMITSU Knapsack Power Duster Model SG-7030. Light-weight, compact design, but ensuring to produce bigger air volume due to high performance turbo-fan be driven by the powerful 60CC gasoline engine. Chemical tank can be quickly mounted or detached by menas of the lock or release lever. Size (L × W × H): 360 × 520 × 740mm, weight: 10.5kg, Max. output:3.7ps/7500rpm, Chemical tank capacity:28*l*, AIr volume: 140m^3/min, Max. static pressure: 990 mm AQ.



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



CHIKUMA Corn Sheller Type3. 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 mess.: 18cft.

ISEKI TXG23 Tractor. Mounted with powerful and economical 22.5PS water cooled diesel engine. The tractor offers wide range of travelling speeds from approximately 0 km/h to 16 km/h, which offers broad operating application and safe road travelling.

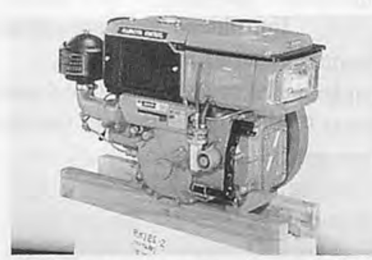
ISEKI SF303 Mower. The 28 hp diesel engine gives you the power you need to deal with all your mowing tasks quickly, while its efficient use of fuel makes it economical as well. Cutting width: 1524/1830 mm, Cutting height: 30-120mm.

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 1.5V batteries. A rechargeable battery pack can also be used.

KUBOTA MX5000 (50HP) 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. This tractor can be operated in dry and paddy field. High performance and great durability!

KUBOTA Combine Harvester SKY ROAD PRO 481. Easy to operate, micro-computerized 4-line combine harvester that cuts down on time as well as crops. Equipped with many helpful mechanisms and a reliable water-cooled diesel engine. Max. output: 48PS/27000 rpm.

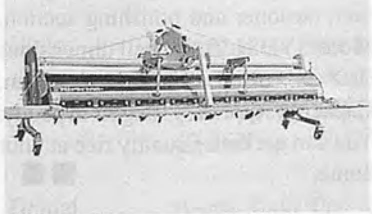


KUBOTA Diesel Engine RK 125. Based on Kubota's advanced engine technology, the horizontal, water-cooled and 4-cycle diesel engine can provide full-bore power with less fuel consumption, higher output, and quick and smooth starting. For power tillers, pumps, generators, welders and other farm and industrial used. Max. output: 12.5 HP/2400 rpm.

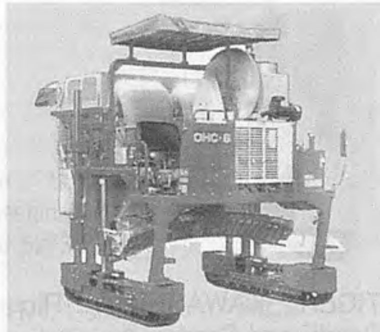
MAMETORA Vegetable Transplanter TP-4. This machine is available in both pot and soil block in seeding transplanting. Application: all vegetable nursery.

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 25 kg/cm^2, Weight: 8.5 kg.



NIPRO Drive Harrow HR-2410B-3S for paddy field. Working width: 244 cm; Required tractor horsepower: 24-40HP.

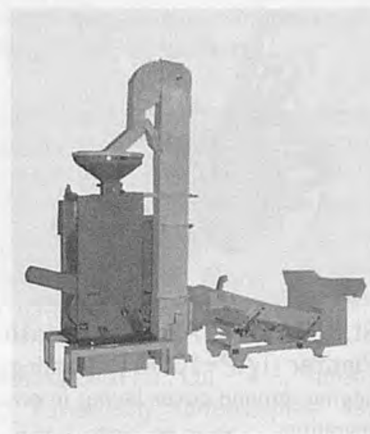


OCHIAI Riding Type Tea Picking Machine OHC-6. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 29PS

OREC Cultivator SF40W. Hobby use: Mounted with 2.4 PS(1.8kw).

ROBIN Brush Cutter Model BF2100(AU). 2 cylinder engine (20cc) makes the lightest model in the wolrd 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: 300*l*. Required tractor horsepower: 20-50PS.

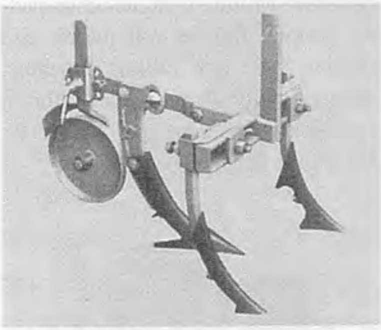


SATAKE Mill Top. Compact Rice Milling Unit including paddy cleaner, Rubber roll husker and friction type rice milling machine. Input capacity: Approx. 650 kg/hr on long grain rice. Required power: 25 PS engine (standard).

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

STAR Mini-Roll Baler MRB 0850. 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 ABLE Potato Planter TAP-100MT. Planting, ridging, ground cover laying in one operation.



SUKIGARA Three-Tine Light Cultivator. Length:51cm, Cultivator width:18 ~ 30cm, Weight:8.5kg .

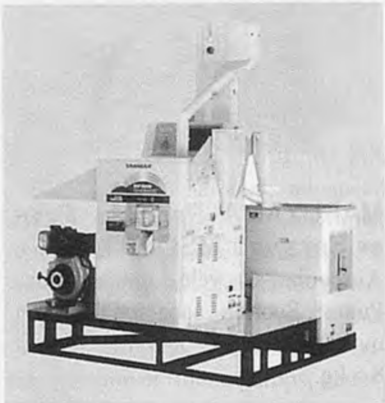
TANAKA 2-Cycle Engine Pure Fire is an environmentally kindly engine that cleared the secondary exhaust fumes control by the U.S. CARB. Both 26cc and 42 types are available. The engine just for the 21st century.

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

UCHIDA Power Tea Picker S-8N & B-3. Handy and simple to opetate. Hair-trimmer type blades protect the tea leaves from damage. You can see the cutting work for transparent case.

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

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



YANMAR Compact Rice Milling Unit. Home use compact rice milling unit, consisting of hulling section, destoner and polishing section. Model: YHS150. Overall dimensions (L × W × H):1.49 × 1.32 × 1.94m. Capacity: Approx. 150kg/hr in paddy. You can get better quality rice at your home. ■■

DIRECTORY

Arimitsu	Arimitsu Industrial Co., Ltd.—3-7, Fukae-kita 1-chome, Higashinari-ku, Osaka, 537-0001. Tel. 06-6973-2030
Bunmei	Bunmei Noki Co., Ltd.—11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890-0065. Tel. 0992-54-5121
Chikuma	Chikumasuki Co., Ltd.—356 Koya, Yoshikawa, Matsumoto-city, Nagano-pref., 399-0031. Tel. 0263-58-2055
Iseki	Iseki & Co., Ltd.—3-14, Nishi-Nippori,5-chome, Arakawa-ku, Tokyo, 116-0013. Tel. 03-5604-7600
Kioritz	Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo,198-0025. Tel. 0428-32-6118
Kubota	Kubota Corporation—2-47, Shikitsuhi-gasgi 1-chome, Naniwa-ku, Osaka, 556-0012. Tel. 06-6648-2111
Mametora	Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363-0017. Tel. 048-771-1181
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Robin	Fuji Robin Industries Co., Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410-0022. Tel. 0559-63-1111
Sasaki	Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomori-pref., 034-0000. Tel. 0176-22-3111
Satake	Satake Corp.—7-2, Soto-kanda 4-chome, Chiyoda-ku, Tokyo, 101-0021. Tel. 03-3253-3111
Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city Shizuoka-pref., 437-0042. Tel. 0538-42-3111
Star	Star Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066-0077. Tel. 0123-26-1122
Sukigara	Sukigara Agricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444-0943. Tel. 0564-31-2107
Tanaka	Tanaka Kyogyo Co., Ltd.—3-4-29, Tsudanuma Yatu, Narashino-city Chiba-pref., 275-0016 Tel. 047-438-4411
Tiger	Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 323-1104. Tel. 0282-62-3001
Uchida	Uchida Hamono Kogyo Co., Ltd.—2123-4, Honjo, Kikugawa-machi, Ogasa-gun, Shizuoka-pref., 439-0018. Tel. 0537-35-2261
Yamamoto	Yamamoto Co., Ltd.—404, Oinomori, Tendo-city, Yamagata-pref., 994-0013. Tel. 0236-53-3411
Yanmar	Yanmar Agricultural Equipment Co., Ltd.—1-32, Chaya-machi, Kita-ku, Osaka-city, 530-0013. Tel. 06-6376-6336

ABSTRACTS

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

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Ergonomic Evaluation of Manually-operated Paddy Transplanter. K. Kathirvel, Associate Professor, Department of Farm Machinery, College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore 641003, INDIA. K. P. Vidhu, PG Student of the same. R. Manian, Professor of the same. T. Senthilkuamr, Research Associate of the same.

Manual rice transplanting is a labour-intensive operation comprising nursery raising, uprooting of the seedlings, transporting and transplanting the uprooted seedlings in the main field, with a total labour requirement of about 280-350 man-hour/ha. High labour demand during the peak periods adversely affects the timeliness of operation, thereby reducing the crop yield. Because of drudgery and notion that the farm operations are below the dignity, labour availability, in general, has decreased considerably in farm operations. Ergonomical evaluation of paddy transplanter can provide a rational basis for recommendation of methods and improvement in equipment design for more output and operator's comfort and safety. Three subjects were selected for the study based on the age and screened for normal health through medical investigations. The parameters used for the ergonomical evaluation of paddy transplanter include heart rate and oxygen consumption, energy cost of operation for all the selected implements, acceptable work load, endurance time, work rest cycle, discomfort ratings and force measurement. Based on the analysis the following inferences are drawn: The mean value of heart rate for operating the transplanter was 136.03 bpm. The corresponding values of oxygen consumption were 1.171 L/min. The energy expenditure for the operation of transplanter was computed as 24.45 kJ/min or 5.82 kcal/min. The operation of paddy transplanter was graded as "heavy". The energy cost of operation in terms of VO2 max was 63.64 per cent. These values were much higher than that of the AWL limits of 35 per cent indicating that the transplanter could not be operated continuously for 8 hours. The work rest cycle for achieving functional effectiveness of the paddy transplanter is 30 minutes of work followed by 14 min rest with two operators. The overall discomfort rate (ODR) was 14.37 necessitating an adjustable handle to accommodate the anthropometric suitability of the subjects and handle grip provision to avoid skin irritation and scale formation in palm. The force required for pushing the handle to pick the seedling and planting, force in pulling the fork back from the soil to the next planting position and the force in pulling the implement in the forward direction was 102, 94 and 129 N, respectively.

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A Consumptive Use Model for Corn (Zea mays) in Port Harcourt Area, Nigeria. J. M. Ayotamuno, Department of Agricultural Engineering, Faculty of Engineering, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, NIGERIA. Email: mjayotamuno@hotmail.com. A. J. Akor, same. E. W. U. Essiet, same. S. C. Teme, same. N. O. Isirimah, Department of Crop and Soil Science of the same university. F. I. Idike, Department of Agricultural Engineering, University of Nigeria, Nsukka, NIGERIA.

A new corn (Zea mays) ET model aimed at predicting water requirements for optimum corn yield during the dry season in Port Harcourt area, was obtained. Actual corn evapotranspiration (ET) values, measured with lysimeters were used to calibrate potential evapotranspiration (PET) values obtained from Duru (1983) and also known as Blaney- Morin- Nigeria (BMN) (1983) model. The BMN (1983) model had ealier been selected as the best model amongst 6 other models to accurately predict corn ET in Port Harcourt area. The results of the statistical analysis of the ET estimates of the new corn model and that of the lysimeter values showed little difference. It is expected that the new corn ET model will give reliable estimates of the crop-water use needed for irrigation schemes during dry seasons in the study area.

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Agricultural Women of India. Bimla, Research Associate, 1008, HBC, SEC-15A, Hisar-125001, Haryana, INDIA. Mamta Dilbagi, College of Home Science, CCS Haryana Agricultural University, Hisar-125004, Haryana, INDIA. Kusum Rana, Assistant Scientist of the same. Sudesh Gandhi, Scientist of the same.

A study was undertaken to see the women's participation in agricultural activities in Kaithal District of Haryana. The study was conducted in the month of October-December 1998. It was observed that the involvement of rural women in agricultural activities was at the extent of 73%. A woman spends 74 minutes to 413 minutes per day in doing her agricultural tasks. Again, it was also observed that the most drudgeries involved in the activities like transplanting, crushing, etc. were performed by the women only. Transplanting was observed as the most drudgery prone activitiy (66.2%) among all the agricultural tasks, crushing and inter-culturing were found in second and third position with the drudgery score 56.9% and 55.2%, respectively. There is urgent need to create decent working conditions to reduce the drudgery of women while doing her agricultural tasks. Women, particularly rural women who participate equally with men should be trained in the modern techniques of agriculture.

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Combine Harvester Performances in a Commercial versus Non-commercial Paddy Estates. Kamaruzaman Jusoff, Professor, Forest Geospatial Information and Survey Laboratory, Lebuh Silikon, Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, MALAYSIA. Swapan Kumar Roy, Research Assistan tof the same.

A study was carried out to investigate the work rate and harvesting losses of New Holland Clayson 1,545 combine harvester used in the Muda Agriculture Development Authority (MADA) Kedah, Kemubu Agriculture Development Authority (KADA) Kelantan, and a commercial paddy estate in Kluang, Johor. Results inferred that the performance in terms of field capacity of the same type of combine harvester was higher (1.15 ha/h) in KADA compared to MADA and Kluang. The average field capacity of the machine was 0.96 ha/h with a corresponding field efficiency of 62%. The recorded grain yielded by combine harvester was more than 4.50 t/ha for MADA and KADA areas and less than 3 t/ha for Kluang area. In a grain loss study for the combine harvester, the total grain losses for three areas were within 2-7% of total yield where the cylinder loss contribute the highest percentage of the total grain loss (67-81%). This cylinder loss could be minimized by the proper adjustment of cylinder in the combine harvester. However, there was no major mechanical or operational problem observed during field operations.

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Farm Tractor Conditions in Botswana. Edward A. Baryeh, P.O. Box KS 14053, Kumasi, GHANA. Obokeng B. Raikane, Botswana College of Agriculture, Private Bag 0027, Gaborone, BOTSWANA.

Tractor owner characteristics and tractor conditions in the Southern Agricultural Region of Botswana have been studied using questionnaires. It was found that 24%, 32%, and 44% of tractor owners were between 31 and 40 years, between 41 and 50 years and over 50 years, respectively, with 62% having primary or no education. The tractors had an average age of 21 years and engine power range of 25 to 110 kW. All of them were used for ploughing. The study further revealed that of the tractors studied, 32% were bought new, 80% were either Massey Ferguson or Ford, 28% had headlights, 12% had turn signal lights, 4% had parking lights, 6% had brake lights, 58% had good tyres, 62% had good brakes, 84% had PTO shaft protector guards, 78% had mounting steps, 42% had good bodies and 34% had good seats. All of them have a dashboard light. The operator workplace dimensions allowed him enough space and levers, pedals and controls were conveniently placed in 90% of the tractors. Tractor noise levels were found to be above EC limits. The noise when ploughing at a speed of 6.5 km/h ranged from 98.6 to 104.1 dBA for engine power range of 20 to 100 kW. Maintenance and repair were irregular due to lack of education, information and money.

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Design Approach to a Safety Cab for Tractor Operator's Comfort. Sahastrarashmi Pund, Research Associate (Ergonomics), College of Agricultural Engineering and Technology, Gujarat Agricultural University, Junagadh - 362 001, INDIA. E-mail: spund@gauj.guj.nic.in. Rajvir Yadav, Associate Professor (Farm Machinery and Power) of the same college. E-mail: ryadav@gauj.guj.nic.in.

With emphasis on increasing awareness of the potential benefits of ergonomic and economic cab design, a low-cost safety cab was developed to improve the working efficiency, safety and comfort of the operators who can not afford to buy an expensive sophisticated cab or air conditioned cab. Subjective scale was developed and the cab was evaluated for its performance on the basis of thermal stress index, subjective assessment, noise level and vibration level. Dry bulb temperature inside the cab was lowered by 2.34 ℃ (i.e., from 32.20 to 29.86 ℃) with thermal stress index in between 3 to 4, giving thermal sensation in comfortable zone, during the peak period of the day. The operations: transportation, harrowing and ploughing as rated by all the subjects were 2.50, 3.00 and 3.20, respectively, on the subjective scale. Noise level was lowered to 83.60 to 86.30 dBA for all the operations whereas vibration levels approach the safe limit only during ploughing. The overall performance of the developed cab was promising in terms of working efficiency, safety and comfort of the operator.

■■

Final Conclusions and Recommendations of the XIV meeting of the Club of Bologna

16,17 Novmber, 2003, Italy.

Conclusions and Recommendations

66 experts from 33 countries and representatives of FAO, CIGR, AIT and UNIDO took part in the XIV Club of Bologna meeting, held on 16 and 17 November 2003 on the occasion of the XXXIV EIMA show, under the aegis of CIGR and with the sponsorship of UNACOMA.

There were three topics under discussion, all to a certain extent interrelated, of which the first was "Reducing the production costs and running costs of tractors and agricultural machinery", with contributions by three Club members representing major equipment manufacturers: J. Deere (USA); Kverneland (Norway) and Yanmar (Japan) as well as the University of Braunschweig (Germany) - Institute of Agricultural Machinery and Hydraulic Power.

The second topic was "Strategies for the development of agricultural mechanisation in African countries: role of governments and the private sector", with a keynote paper by L.J Clarke, representative of FAO. Finally, the third topic was "Progress made and activities completed in relation to traceability", with an introductory presentation by Y. Sarig (Israel), on behalf of a working group comprising H. Auernhammer (Germany), L. Bodria (Italy), H. Cetrangolo (Argentina), I. De Alencar Naas (Brazil), J. De Baerdemaeker (Belgium) and Ph. Marchal (France).

Conclusions

1. Reducing the production costs and running costs of tractors and agricultural machinery.

The first of the three introductory papers setting forth the perspective of industry was given by J. Reid (USA) in collaboration with W. Norris (USA) and J. Schueller (USA); the second by E. Niemeijer (Holland) and the third by T. Kobayashi (Japan). All three presentations focused on the industrial side of the problem, underlining that production costs can be effectively reduced through the application of specific modern management methods. In particular, significant advantages may be obtained from: a more rational internal organisation of factories; standardisation of machines and their components; modularisation; increased interchangeability of components, so as to also reduce the cost of after-sales service and spare parts. One particular area of increasing interest, according to Reid, is the use of electronics and mechatronics to accomplish more appropriate and cost-effective agricultural management. In addition, Reid, Norris and Schueller noted the necessity of differentiating the design approaches for the industrialised and emerging countries. Niemeijer pointed out the importance of improving internal organisation to reduce R&D costs, and taking greater care in the selection of dealers, who must have the most modern and appropriate equipment for answering the needs of purchasers. Kobayashi then emphasised the importance of modularity, and the deployment of electronics and IT as means of reducing costs at both the industrial and agricultural level. H.-H Harms (Germany) finally reasserted the need to shorten the development cycle of innovative products, and to this end described the "S.E. Simultaneous Engineering" method, under which the various phases of production are carried forward concurrently by interdisciplinary teams working in collaboration. The greatest advantage afforded by the S.E. method is a faster development cycle for new products which must be extensively tested in the field. This field work --coupled with the involvement of dealers --becomes more and more important as the complexity of machines increases.

2. Strategies for developing agricultural mechanisation in the African countries: role of governments and the private sector.

The presentation by L.J. Clarke began by recalling FAO's contribution to the definition of guidelines on the proper role of mechanisation in agricultural development, based upon observations in various developing countries, where farmers have had real difficulty accessing mechanisation and related services. Hence the need for the private sector to play its part, by taking into consideration the needs of farmers, dealers, manufacturers and importers. This with the ultimate aim of determining the most appropriate forms of mechanisation as a function of: the specific organisational and economic situation of the farms, the possible forms of credit, the role of contractors and agricultural machinery user groups, the available level of technical service, and the existence of local support organisations The collaboration of agricultural machinery importers, manufacturers, distributors and dealers is of course a necessity.

Governments, on their part, should be putting in place policies for promoting more rational development of local industry and agriculture, as well as addressing infrastructure and employment issues, and providing assistance for research, development, testing and technical training.

3. Progress made and activities completed in relation to traceability.

The presentation by Y. Sarig was the logical continuation of the discussion undertaken on this subject during the two Chicago and Bologna sessions in 2002. Taking into account that traceability is now incorporated into both the ISO regulations and those of various nations including the USA, EU and Japan, the report was subdivided into the following sections: definition of traceability, reasons why it is needed, and means by which it can be achieved; practical aspects of its application, including the innovative electronic and IT systems, sensors and computerised field logs that must be installed on the various agricultural machines, in order to implement traceability at both the production and post-harvest stages. There followed a discussion of the role that the Club of Bologna should play, also with regard to strengthening the links between producers and consumers for the purpose of assuring food safety. An essential prerequisite for the validation of the various traceability systems is the definition and adoption of innovative technologies developed specifically for that purpose.

Following an extensive and in-depth discussion of all three topics, the participants formulated the following

Recommendations

Topic 1

- Having noted that the representatives of industry limited their analysis to the manufacturing-related aspects, and did not mention the problems of optimisation at farm level, which would need to be implemented through choices geared to the specific local conditions of different agricultural systems;

- Acknowledge that standardisation and modularisation of components is one of the primary routes for reducing costs; that a fundamental contribution in this respect can be made by novel CAD and CAM solutions--an area in which much still remains to be done; that considerable attention should be devoted to the application of "Simultaneous Engineering" systems for the concurrent development of new products by interdisciplinary teams, with the dealer networks also involved in the process from the outset;

- Concur on the importance of localised approaches geared to the mechanisation needs of developing countries, especially with regard to the ease of use of machines. Whereas in the industrialised countries standardisation of components should be pursued as a route toward simplifying maintenance.

- Confirm that: in all cases: it is necessary to shorten the development cycle of new products, as well as improve the marketing of spare parts and the training of dealers and sales staff;

- Recommend the introduction of "teleservice" remote technical support as a means of reducing costs;

- Underline the need to: upgrade the quality level of dealers, by providing them with improved and up-to-date technologies; give maximum importance to feedback received from end consumers (farmers and contractors); develop machines able to meet the needs of precision farming; encourage technology transfer towards countries with lower labour costs; foster wider-ranging collaboration between manufacturers, farmers and research and development institutions.

Topic 2

- Having recognised the need to define precise guidelines that can enable governments of African countries to facilitate access to mechanisation that is appropriate, simple and low cost;

- Underline the importance of acquiring sufficiently detailed information about the agricultural systems of the various countries, the available forms of financing and credit, and the utilisation of labour by both the private and public sector;

- Reassert the overarching need to: provide the various countries with efficacious irrigation systems, means for transporting farm inputs and crops, appropriate product storage technologies and simple manual or animal-drawn tools, while at the same time promoting the establishment of machinery sharing centres (cooperatives, etc.) that can directly aid farmers.

- Recommend that the Club of Bologna make a contribution through the provision of assistance to developing countries, in particular by promoting technical meetings and field demonstrations, as well as training workshops on the maintenance and repair of the most appropriate machines, and through the establishment of local dealer networks;

- Underline the fact that such actions must be capable of delivering tangible benefits to the economies of both emerging and industrialised countries, by helping to define the most appropriate technical-economic solutions for the transfer of specific technologies.

Topic 3

- Having recognised the need to promote further research and development on the instruments that must be installed on tractors and agricultural machines, and in particular the sensors, I.T., electronics, and computerised field logs necessary for the traceability of plant and animal productions;

- Recall the fact that traceability is now a requirement under the ISO regulations, as well as those of the USA, the EU, Japan and other major countries;

- Recommend that the Club of Bologna set up working groups of its members charged with:

  · helping to establish--in collaboration with chemists and biologists--the physical, chemical and biological parameters to which each product must conform;

  · defining the requirements of international standardisation aimed at the assurance of food safety;

- Emphasise the importance of close collaboration between industry and research for the practical implementation of product traceability, and of keeping farmers, contractors and processing factories fully informed of the decisions taken concerning the appropriate use of these new, essential technologies.

http://www.clubofbologna.org

EuroTier 2004
November 9-12 2004
Hanover GERMERY

Starting signal fired for EuroTier 2004

From 9 to 12 November 2004 in Hanover - In focus: livestock management in the new, larger Europe - Deadline for registrations: 2 February 2004

(DLG). The next EuroTier, the leading European exhibition for professional agricultural livestock management, will be held in Hanover from 9 to 12 November in the second week of November 2004. The German Agricultural Society (Deutsche Landwirtschafts-Gesellschaft, DLG) as organiser has already started preparations by sending out the registration papers to exhibitors. The last International DLG Exhibition for Livestock and Poultry Management attracted over 120,000 visitors, including over 17,000 from outside Germany - a major success story.

The Exhibition programme of EuroTier 2004

EuroTier 2004 will once again be the platform for supply and demand in international livestock and poultry production. It pools the complete international range of supplies and services for pig and poultry farmers, as well as for milk and beef producers. In addition EuroTier 2004 is expected to provide a greater programme for sheep farmers and fish producers. The Exhibition programme is divided into altogether thirteen groups:

· Breeding stock, breeding programmes, trade, reproduction technology
· Farm inputs
· Feed storage, feed production
· Animal housing and shed construction
· Management and feeding technology
· Climate-control, energy and environmental technology
· Milking and cooling technology
· Technology for dung, solid and liquid manure
· Transport vehicles and transport services
· Processing and marketing
· Equipment, accessories and spare parts
· Management and consultancy
· Information

Tel+49/(0)69/24788-259, Fax +49/(0)69/24788-113, E-mail: G.Ott@DLG-Frankfurt.de
WEB www.eurotier.de.

FPEC 2004
Fukuoka
September 7-11 2004
Fukuoka JAPAN

Background and Objectives

The world's population increased to more than 6.1 billion in 2002, and therefore the global environment is certain to go from bad to worse. In this situation, the atmospheric and aquatic environments are very important subjects for the 21st Century. The deterioration of these environments will create a food problem and has already begun to cause international disputes in some parts of the world.

Threats to the global environment consist of global warming, desertification or land degradation, acid rain, El Nino, deforestation, the destruction of the ozone layer and so on. These matters affect mainly the atmospheric environment on a global scale. Under these conditions, an assessment of the environment is necessary in order to continue agriculture, and environmental conservation is indispensable if the environment is to continue to support human life. We therefore hope that safe and low-priced foods will be produced from now on.

In this symposium, we will evaluate the meteorological environments ranging from the global atmospheric environment to microclimates, and discuss ways to improve and conserve atmospheric environments. In order to find out various possibilities to solve the food problem, we focus our discussion on individual and/or general environmental problems with the participation of researchers, professors and administrators from around the world.

The main currents of discussion will be as follows: First, the relationships between climatic variation or climatic change and

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abnormal weather, meteorological improvement from global-climatic to micro-climatic scales, and bio-environmental control; second, micro-meteorological analysis of various fluxes under various conditions and the evaluation and utilization of climatic resources; third, global environmental problems of desertification and yellow sand, desert greening of arid lands and agricultural disasters; fourth and finally, we will widely discuss food problems from the standpoint of crop prediction or food production.

The symposium is the second part of "Food Production and Environmental Improvement under Global Climate Change", which was held at Ube, Yamaguchi, from July 30 to August 2, 1996. Therefore, some reflection on the developments that have occurred since those days should be undertaken in this symposium. The results of that reflection should bear significantly on future developments. It is significant meaning that the development process after then will be increased. We hope and believe enthusiastically that the future prospect on food production and environmental conservation will be improved by the process of discussion and that the development of researches and investigations will be improved finally in agricultural meteorology, the global atmospheric environment and so on.

Organized by

The Society of Agricultural Meteorology of Japan

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All correspondence should be addressed to Prof. Seiji HAYAKAWA, Secretary-General of FPEC, Department of Biological and Environmental Sciences, Faculty of Agriculture, Yamaguchi University, 1677-1 Yoshida, Yamaguchi 753-8515, JAPAN

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Automation Technology for Off-road Equipment

October 7-8, 2004

Kyoto, Japan

Sponsored by:

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Endorsing Organizations:

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PURPOSE : To promote the advancement of automation of off-road equipment in the 21st Century through scientific exchange and industrial participation.

TOPIC AREAS: Papers are being solicited that address topics including but not restricted to the following:

o SENSORS: Navigation and control sensors, sensor fusion, sensors for safety/obstacle detection, machine function sensing;

o CONTROLS: Steering control, vehicle control, control strategies for off-road operation;

o VEHICLE MODELING: Vehicle kinematic and dynamic modeling, implement modeling;

o TELEMATICS IN VEHICLE AUTOMATION: Wireless networking in off-road applications;

o SOFTWARE SUPPORT FOR VEHICLE AUTOMATION: Production planning, scheduling and control, Job-site management, mission planning;

o INFORMATION TECHNOLOGY: Cooperative robots andmulti-agent systems, prognostics, intelligent systems;

o HARDWARE FOR VEHICLE AUTOMATION: Computer hardware, user interfaces, haptic devices, controller-area networks; and

o APPLICATIONS: Automation of Off-road equipment, industrial products and applications.

For conference information contact:

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http://www.asae.org/meetings/atoe04/index.html

26th Intenational Conference of CIGR Section 4th Electricity and Energy in Agriculture, in Rural Development and in Habitation Management

May 17-22, 2004

Budapest, Hungary

Main Topics

The possibilities for agricultural farms, instead of being energy comsumers to become energy comsumers to become energy producers by the use of renegerative energy sources. The using possibilities of the new wind-technology in agriculture. Economical using possibilities of regenerative energy sources in agriculture and habitation management on the developing countries. Actual questions relating to the application of electrical energy in agriculture. ■■

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b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are printed, **double-spaced**, under 3,000 words (approximately equivalent to 6 pages of AMA-size paper) ;
g. are supported by authentic sources, reference or bibliography ; and those that
h. are written on floppy disc

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b. When an article is accepted but required revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. The AMA does not pay for articles published. However, the writers are given collectively 2 free copies (one copy air-mailed and the other sent by surface/sea mail) of the AMA issue wherein their articles are published. In addition, a single writer or a responsible writer is given 20 off-prints of the article along with 2 more free copies of the issue while joint writers are given 5 off-prints (also sent by surface/sea mail).
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c. The article must bear the writer(s) name, title/designation, office/organization, nationality and complete mailing address.

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c. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
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   v) conclusion/recommendation ; and a
   vi) bibliography
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be numbered. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e.g., "Figure 1. View of the Farm Buildings".
e. **The data for the graph must also be included (e.g., EXCEL for Windows).**
f. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
g. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
h. Express measurements in the metric system and crop yields in metric tons per hectare(t/ha) and smaller units in kilogram or gram(kg/plot or g/row).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the latter consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. When numbers start a sentence, such numbers must be written in words, e.g., "Forty-five workers..." or "Five tractors..." instead of "45 workers..." or "5 tractors..."

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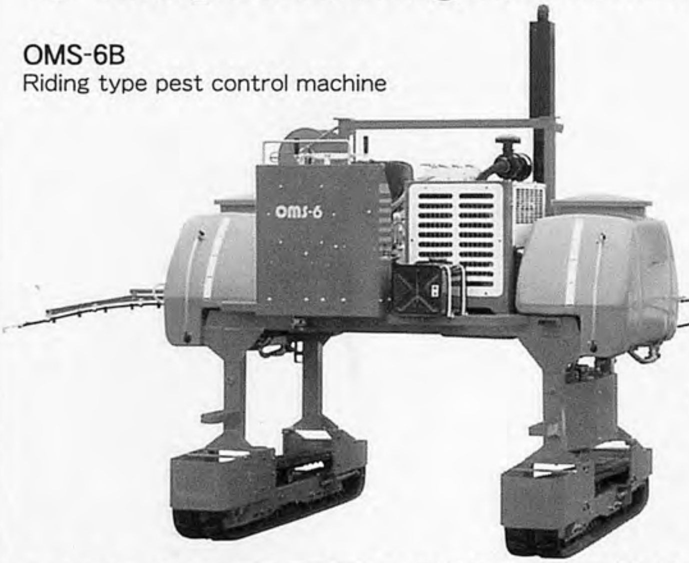

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