AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH #28

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture — AN2C-0000-0000

B. SECONDARY: Farm equipment

2. TITLE AND SUBTITLE

Use of mechanical power for rotary weeding

3. AUTHOR(S)

Navasero,N.C.; Khan,A.U.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	7p.	ARC 631.35.N322

7. REFERENCE ORGANIZATION NAME AND ADDRESS

IRRI

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(In Pans,v.16,no.1.p.87-92)

9. ABSTRACT

10. CONTROL NUMBER

PN-RAB-578

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Cultivation
Power equipment
Rice
Weed control

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-2541 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

8

PAN.

cod 2541 Rev.

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Use of Mechanical Power for Rotary Weeding*

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Weed control significantly affects rice yield. A joint UPCA†-IRRI experiment had shown that weeds reduce rice yields by as much as 36%. Available Institute data show that an average of 120 hours is required to hand weed one hectare. A push-type rotary hand-weeder reduces this labour requirement to 70 h/ha. In many areas, high costs and problems of application limit the use of herbicides for weed control.

Rice planting in rows has made possible the use of a rotary hand-weeder, thus reducing the labour requirement. However, the push-type manual rotary weeder has to be pushed two or three times to obtain satisfactory weeding performance. It is desirable to multiply the human effort by the use of mechanical power.

Although small tractors have adequately replaced human and animal labour for ploughing, harrowing and puddling, they cannot function satisfactorily for weeding because of the extremely soft field conditions. The weeds are turned under the soil, generally at a very shallow depth, by manual rotary weeders. A mechanically-powered machine, which is ground-supported for motion, tends to sink deeper than the desired weeding depth and also requires uncultivated headland areas for turning at the end of the rows.

It was felt that the problem could be solved by having the operator support the weight of the machine to provide the desired mobility and turning capability. Many Japanese manufacturers have developed lightweight engine-driven saws which are mounted on the operator. A similar possibility for applying power for weeding is being studied. Improved mounting and better balance of machine would have to be achieved for a multi-row weeder as it would be heavier than the portable saws. The weeding head design should provide adequate flotation to avoid bogging in soft areas. It should have enough slicing and cutting action to scrape the top soil and assist in mixing and burying the weeds. A multi-row weeding rotor should provide adequate clearance between the axle and the rice plants. Handling characteristics and operator comfort during weeding and turning at the end of the rows need to be studied.

A three-row power weeder (Fig. 1), weighing 24 kg, and using a light Japanese portable saw engine, was designed. Many different shapes of blades were tried to achieve proper weeding performance. Weeding performance was satisfactory; however, the load distribution and mounting arrangement on the operator needs improvement. Work was concentrated to (1) determine the optimum rotor diameter, rev/min and axle clearance, (2) determine the optimum blade design and arrangement for optimum flotation, and mixing of weeds in the mud, and (3) determine the optimum suspension and mounting system of the mechanical weeder on the operator.

The machine used a back-mounted 50 cc two-stroke high-speed petrol engine equipped with a centrifugal clutch. The power from the engine was transferred through a partly flexible shaft to a 40:1 reduction worm gear-box. Three weeding rotors were mounted on the worm gear-shaft which rotated at a speed of 110-130 rev/min. The worm gear-box offered high speed reduction with minimum addition of weight. The weeder rotors were further tested and modified to provide self-cleaning action, adequate ground support, and enough cutting-scraping action for proper weeding. The blades were designed to provide adequate ground reaction and avoid excessive machine sinkage. The cutting and scraping edges of the blades were designed for a very shallow working depth of 2 to 3 cm (Fig. 2), since a greater depth would consume power without any additional benefit.

*Paper presented to the Philippine Society of Agricultural Engineers on 9 August 1969 at IRRI Auditorium.

†University of the Philippines College of Agriculture.

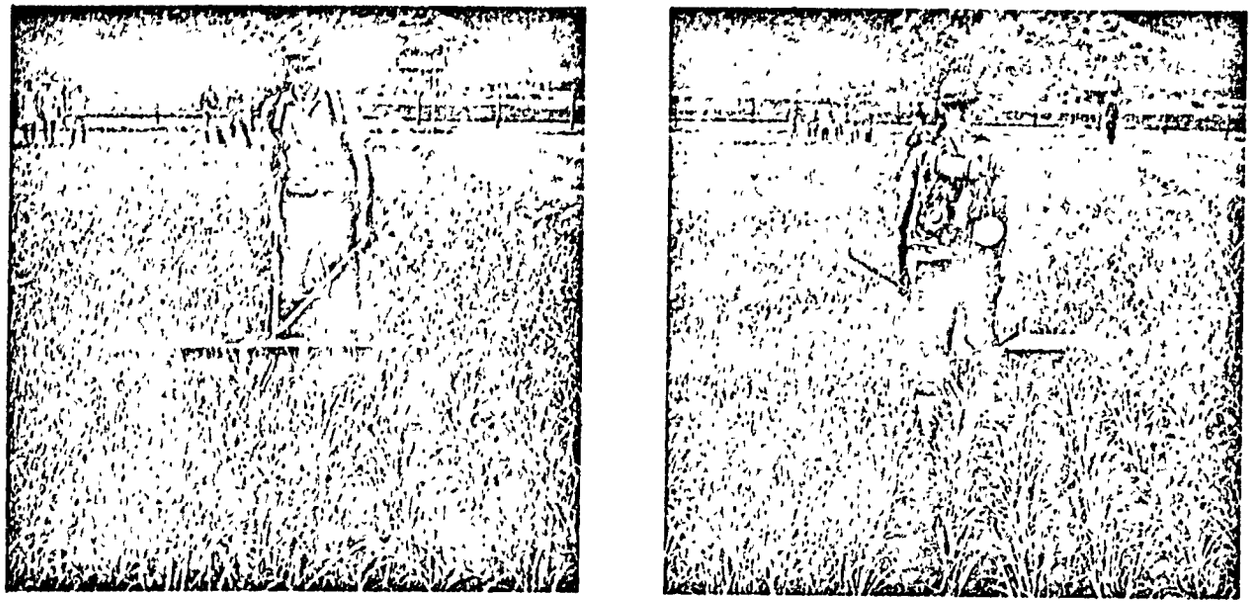

Fig.1. Front and rear views of the experimental flexible shaft three-row power weeder.

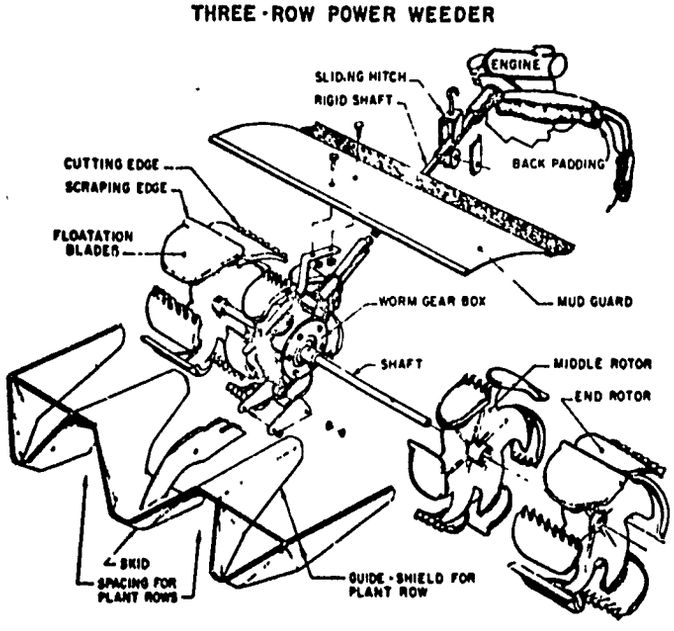

Fig.2. Exploded drawing of first prototype power weeder.

Rotor blades and spokes were designed in such a way as to prevent weeds and mud from clinging to them. The 12½ in diameter rotors equipped with six blades provided good slippage with minimum traction and shallow soil-working ability.

In their early growth stages, rice plants are flexible and can be safely bent to a 3-4 in height. A 12½ in diameter rotor provides enough axle clearance for the plants in the rows to bend and pass under during weeding. In some fields at IRRI, 18 in tall rice plants were weeded with this machine. The plants were able to stand erect again after weeding without any adverse effects. Guide-shields have been attached to the machine to direct the rows of rice plants into the space between the rotors. These shields also prevent the plants from getting caught by the edges of the rotor blades. Two blade-mounting arrangements were built for easy adjustment to suit the considerable variation found in row spacing. The minimum clearance between two rotors for one row of plants

is 9 cm. In crops planted at 25 cm row spacing, a width of 16 cm is available for each weeding blade. It seems difficult to maintain the minimum 9 cm spacing for rows if fixed-width blades are used for all row spacings. Blades of variable width may have to be designed to meet the variations in row spacing.

There were also efforts to reduce operator fatigue by reducing the weight of the machine and studying the various suspension and mounting arrangements of the machine. The flexible shaft arrangement of the first experimental machine permitted the strapping of the engine on the operator's back. During weeding only 12 kg out of the total weight of 24 kg was supported by the operator. However, at the end of the row, the operator also had to lift the weeding rotor weighing 12 kg which was located at the end of a 1.2 m long shaft. Considerable effort was required to do this.

It was felt that an alternate design in which the engine weight could be balanced against the rotor weight would result in reduced lifting effort at the ends of the rows. A second machine was designed (Fig. 2) in which the engine and weeding rotor were connected by a long rigid shaft. A sliding hitch suspension enabled the operator to balance the engine against the rotor when turning at the end of the rows. This arrangment has been preferred by most of the operators who have used this weeder. As the engine and reduction gear-box of the first experimental machine were heavy, a smaller 32.5 cc engine and lighter worm reduction gear-box (35:1) were used in the second experimental machine.

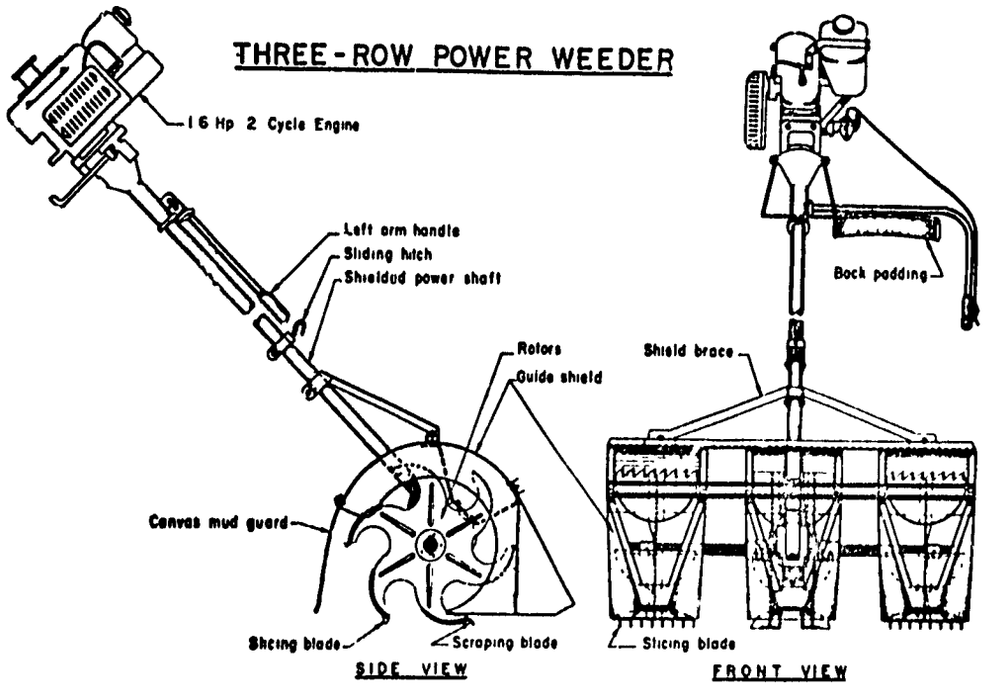

Fig.3. Final prototype three-row power weeder developed by the IRRI Agricultural Engineering Department.

During the preliminary trials, problems were encountered with the plant guide shields. Lighter but rigid guide shields (Fig. 3) were later developed for this 3-row weeder. The weeder with the new guide shields weighed 19 kg, a reduction of 5 kg on the earlier design.

A new 5-row power weeder (Fig. 4), weighing 27 kg, was also designed using a 50 cc engine and the new type of plant guide shields. During the preliminary trials, the engine was found to have sufficient power to operate the 5-row weeder; however, the machine was too heavy and difficult to operate. The test, therefore, was concentrated on the 3-row weeder.

Fig. 4. (left). Experimental five-row rigid shaft power weeder. Fig. 5. (right). Experimental three-row rigid shaft power weeder operating in an extremely weedy rice field.

TABLE 1. PERFORMANCE TEST OF IRRI POWER WEEDER ON DIFFERENT PLANT HEIGHT*

Plot	Plant age (DAT)†	Plant height (cm)	Rate of machine (man-h/ha)	Fuel consumption (l/hr)	Hills damaged per ha	Remarks
1	18	10-20	18.5	0.72	666	Hills buried in soft mud which did not recover as inspected 10 days after weeding.
	18	10-20	20.8	0.71	832	
2	22	20-25	16.4	0.74	0	Fairly good performance: damaged hills were mostly those not in a straight row.
	22	20-25	13.9	0.75	56	
3	24	25-30	13.8	0.70	83	
	24	25-30	12.4	0.66	50	
4	26	30-35	16.7	0.69	33	
5	38	41-50	12.0	0.66	0	Plants that had been bent during weeding were found to have recovered, as inspected 10 days after weeding.
	38	41-50	13.9	0.62	0	
6	50	60+	20.0	0.75	400	Bent and broken tillers; sprouts seen growing as inspected 10 days after weeding.
		Average	15.84	0.70		

*Data taken from results of 30-minute trials.

†Days after transplanting.

IRRI power weeder test

During the 1968 dry season, the portable 3-row IRRI power weeder (Fig. 5) was tested on rice plants at different growth stages to determine whether the 5 in rotor axle clearance was sufficient for the plants to bend and pass under the axle without any significant damage.

Table 1 lists the age, height of the plants, the rate of weeding, fuel consumption, and the number of hills damaged during one weeding operation. The machine required an average of 15.84 man-hours to weed a hectare and consumed 0.70 l of fuel per hour (11.09 l/ha). The ideal plant age to avoid physical damage during weeding ranges from 22 to 38 days after transplanting.

Comparative evaluation of IRRI power weeder

An experiment was conducted in the 1968 wet season to compare the performance of the IRRI 3-row weeder with the commonly practised and recommended weeding methods under lowland conditions. The effect of the weeders on rice yields, weed growth and plant damage were evaluated. Chianung 242 and IR8-68 were transplanted in a field which was subdivided into plots with 1 m strip in between to accommodate the mechanical weeder. The plots treated with herbicide were enclosed by levees to prevent the diffusion of the chemicals to

TABLE 2. A COMPARATIVE EVALUATION OF WEEDING METHODS IN FLOODED RICE, IRRI, 1968 WET SEASON

	IR8		Chianung 242				Evaluation of weeding returns (kg rough rice/ha)			
	Weeds at 45 DAT[1] per m²	Weed weight at harvest (g/m²)	Weeds at 45 DAT per m²	Weed weight at harvest (g/m²)	Yield means[2] (kg/ha)	Labour (man-h per ha)	Rice earned per man-h	Cost of labour[3]	Cost of chemical and petrol[4]	Yield increase (net of weeding cost)
1 Rotary weeding X 2	84	56.33	196	320.00	2416[b]	200	6	350	0	862
2 Hand weeding X 2	58	24.67	122	110.00	2966[ab]	500	4	875	0	887
3 IRRI power weeder X 2	106	23.33	177	133.67	2939[ab]	50	35	88	85	1562
4 Rotary weeding fb hand weeding	149	13.33	120	35.33	2827[ab]	310	5	542	0	1081
5 IRRI power weeder fb hand weeding	93	7.33	133	150.67	2779[ab]	320	5	560	37	978
6 Rotary weeding X 1	96	139.33	214	242.33	2426[b]	90	14	158	0	1064
7 Hand weeding X 1	44	26.33	117	202.00	3604[a]	240	10	420	0	1980
8 IRRI power weeder X 1	94	129.00	145	340.67	2328[b]	25	45	44	42	1038
9 MCPA fb rotary weeding	18	20.33	57	32.33	3180[ab]	104	19	182	35	2193
10 MCPA fb hand weeding	2	2.67	9	25.00	3084[ab]	260	7	455	35	1390
11 MCPA fb IRRI power weeder	9	0	10	38.33	3657[a]	36	68	63	73	2317
12 Trifluralin + MCPA (G)	6	7.67	8	16.33	3546[a]	8	293	14	256	2072
13 Nitrofen + 2,4–D IPE (G)	0	0	0	8.67	3285[ab]	11	189	19	266	1796
14 EPTC + MCPA (G)	0	0	1	12.33	2777[ab]	8	197	14	266	1293
15 No weeding (control)	385	214.67	339	550.00	1204[c]		CV(b) = 24.6%			

[1] Days after transplanting.

[2] Any 2 means followed by the same letter are not significantly different at 5% level by the Duncan multiple range test.

[3] Cost of labour–P0.50/man-h = 1.75 rough rice. (1 Philippine peso = US $ 0.26 = approx. 25s 0d sterling)

[4] Cost of (a) chemical: Trifluralin + MCPA (0.7 + 0.4 kg active ingredient/ha) = P73.
Nitrofen + 2,4–D IPE (G) (2.0 + 0.8 kg active ingredient/ha) = P76.
EPTC + MCPA (1.75 + 0.7 active ingredient/ha) = P76.
MCPA (0.8 kg active ingredient/ha) = P10.
(b) petrol consumption/ha = P12.

fb = followed by.
G = granular.
IPE = isopropyl ester.

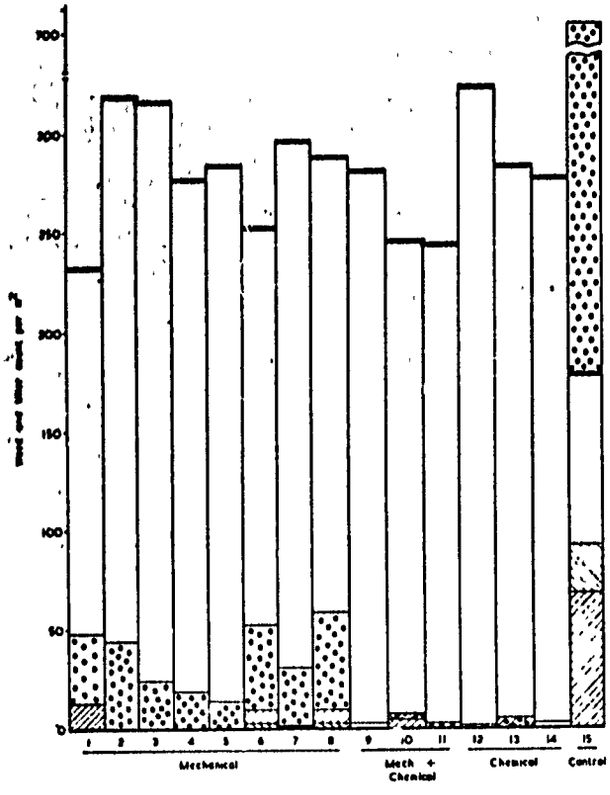

Fig. 6. Effect of different weeding methods on weed population and tillers per m^2 of IR8-68 at 45 days after transplating, IRRI wet season 1968.

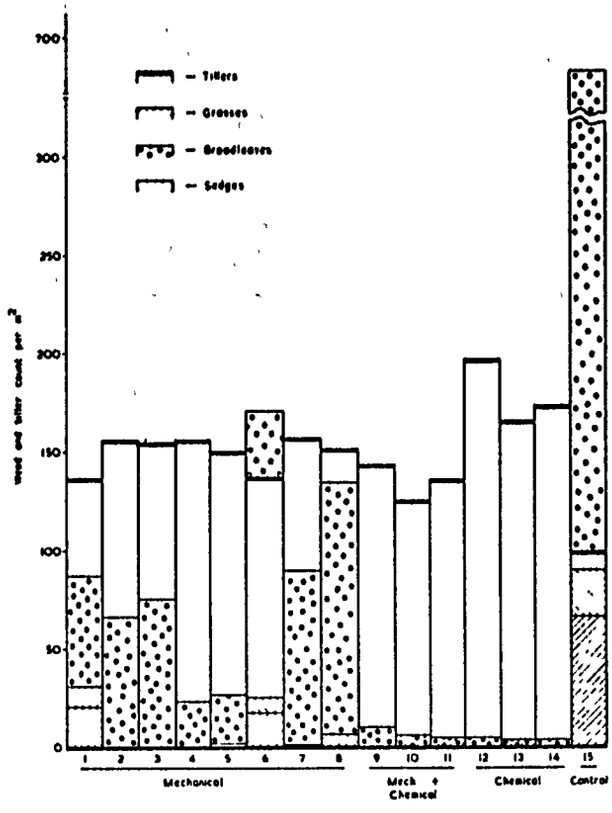

Fig. 7. Effect of different weeding methods on weed population and tillers per m^2 of Chianung 242 at 45 days after transplanting, IRRI wet season 1968.

adjacent plots. The field was fertilised with 70 kg of ammonium sulphate during the last harrowing. Grass was seeded two days after the fertiliser was applied. Standard water management and optimum pest control were practised during the test.

Only a few grass seeds germinated in the control plots. It seems that the broad-leaved *Monochoria vaginalis* (L) Presl. outgrew grass owing to its early stand.

Figs. 6 and 7 show the effects of different weeding methods on tiller and weed count at 45 days after transplanting. A highly significant difference in weed population was observed between the control and the treated plots. The experiment indicated that the mechanical treatments (1 to 8) showed more weeds than those treated with herbicides. There was no significant difference among the mechanical methods of weeding (manual weeding, manual rotary weeding and power weeding). There was a fairly uniform number of tillers per m^2, indicating that the number of tillers damaged during weeding was minimal.

Rice yields, weed weight at harvest, and other data are shown in Table 2. Plots treated with MCPA and then weeded using the IRRI power weeder gave the highest yield, and the highest increase in rough rice net of weeding cost. The most expensive weed control treatments were hand-weeding and manual rotary weeding.

Manufacturers of portable rotary saws have shown interest in the design of this machine, and drawings and test reports are being forwarded to them. It is felt that a lightweight portable power unit with a number of quick-change attachments such as weeder, harvester and sprayer can find a substantial market in the tropical rice-growing countries.

Acknowledgment

This paper is published by courtesy of the Director, the International Rice Research Institute.

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