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DIRECT SEEDING AND TRANSPLANTING OF RICE

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SUMMARY

There are several ways of establishing a stand of rice, ranging from broadcast sowing to transplanting of seedlings. Mechanical devices for performing these operations are in use, and others are being developed. This paper reviews these developments and offers comments on their agronomic implications.

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DIRECT SEEDING AND TRANSPLANTING OF RICE

V. E. A. Wikramanayake

The establishment of a stand of rice has been one of the major problems in the mechanization of rice production. Substantial increases in yield resulting from recent advances in varietal improvement, pest and disease control and fertilizer application, have necessitated a concomitant improvement in stand establishment techniques to make the best use of these advances, as well as to decrease the cost of production. Unlike other crops, rice lends itself to many variations in the method of stand establishment, and one can find a method to suit nearly every set of conditions of climate, soil, water supply, labor availability or standard of technology.

BROADCASTING

The broadcast seeding of rice under upland conditions is prevalent under the most primitive types of cultivation for rainfed crops. Under lowland conditions, however, the current practice of broadcasting, though simple enough per se, involves a high standard both of land preparation and of pre-germination of seed. Rice seeds sown on mud need to be in contact with air in order to germinate and therefore cannot be submerged. Pre-germination of seed prevents their sinking in mud and also gives the seedlings a "head start" over weed seeds. Levelling must be precise to avoid pockets of standing water. It is absolutely necessary that the field be puddled and levelled carefully and accurately, so that water can be controlled on the surface during the early period of growth. Seedbed preparation for this technique requires large inputs of labor, and skill. There are many regions where the technical excellence of this operation (coupled with the high degree of uniform broadcasting ability) is traditional. In the current context of rice production technology, the practice of broadcasting has disadvantages because of the difficulty of manual and mechanical weeding and the application of agro-chemicals. For example, it is reported (11) that broadcast fields in the Elahera project in Ceylon last season, were all but wiped out by gall midge attack solely because of the difficulty of proper management, while the attacks on row-sown and row-transplanted rice were satisfactorily controlled.

While the above is generally true as far as farmers' fields are concerned, the experiment stations have been able to produce high yields from broadcast sown rice. Reports from IRRI (12) and elsewhere have shown that it is possible to obtain high yields from broadcast sown fields provided that good management of water and agro-chemicals is practised. There are also definite indications from work at IRRI (13), that it is possible to obtain yields of 8 tons per hectare from broadcast sown fields with no preparatory tillage at all, but by practising good water management, by using herbicides and by the judicious application of fertilizer. What is possible in the experiment station is often neither possible nor immediately desirable under conditions prevailing in the farmers' fields. In many Asian countries, foreign exchange is lacking and labor is not, and techniques of production involving the minimum foreign exchange component are desirable.

The problem of weed growth is diminished considerably if rice is broadcast sown into standing water (as practised in California), and until

recently there was but meager hope that this practice could be feasible under tropical conditions. Recent work at IRRI (14) indicates that not only is it possible to establish stands of rice by broadcasting into standing water, but also that such a practice does not lower yields significantly. The progress of these studies hold out much hope in solving problems of stand establishment and weed control in rice.

Broadcast sowing of rice has a special advantage when growing desirable varieties whose only possible undesirable quality is poor tillering. By and large, however, the direct seeding of rice in regularly spaced rows, is not only conducive to good management, but makes it possible to substitute manual operations for chemicals (involving foreign exchange) in the control of weeds, especially in farmers' fields. Broadcasting may well become a future "improved practice" among farmers, schooled in good management through row-seeded crops!

STRIP CULTIVATION

The technique known as strip cultivation was first suggested in Ceylon by Wickramasekera (1938) and Niseki (1957)(1) and developed and made a practical proposition by Manickavasagar (1968)(2). It is a simple method of converting a broadcast field into an ostensibly row-sown one by the use of a Japanese-type manual weeder to eliminate rice plants and weeds in "inter-row" areas, leaving regularly spaced strips of plants. The operation can be performed by a small 2-wheel tractor equipped with four rotary weeders, or by the IRRI mechanical weeder. Subsequent weedings are done as and when needed, and the crop is, to all intents and purposes, a row-seeded one. This technique is wasteful of seed material, but the advantages are many, both in time saved and in the creation of suitable conditions for good crop management. Above all, it has served to improve cultivation technique among farmers who traditionally broadcast their crop without rendering redundant their high degree of skill in land preparation and broadcast sowing. It is recognized, however, that this method is only a transitional technique in establishing the advantages of row seeding among traditional rice farmers.

DIRECT SEEDING IN ROWS

The problems associated with the mechanization of row seeding rice are considerably reduced if the operation is performed under "dry conditions", as for upland crops. Seeders and mechanisms already available may be used with dry seed. This method of seeding is practicable in areas (such as the Kanto plain of Japan) where water control is good, or in rain-fed areas (like the Kekulan fields in Ceylon). Under the latter conditions, uncertain rainfall introduces the risk of crop failure. Standing water is not necessary for stand establishment, and on dry sown crops, water can be impounded at a later stage of the crop growth. Several firms in Japan market such seeders; most notable are those coupled to the rotary tiller of 2-wheel and 4-wheel tractors. In these mechanisms, fertilizer is distributed ahead of the rotary tiller and the seeds drilled in furrows behind it. This arrangement enables tillage and seeding to be combined in one pass under suitable conditions.

Work is being conducted in other countries as well to develop cheap and effective machinery for this purpose. In Ceylon, the Designs and Testing

Center, Maha Iluppallama, has designed, built and tested two types which are proving satisfactory. A centrifugal seeder was originally designed for the 4-wheel tractor owner-contractor, who invariably possesses a 9-tined cultivator. The seeding mechanism and plastic seed tubes are mounted on the cultivator, which serves to open furrows for sowing the seed. The seeding mechanism is simple, consisting of drums containing seed rotating on a horizontal axle and driven by a chain transmission from a ground wheel. Centrifugal force throws the seed through holes in the drum onto the cover and thence through the seed tubes. Seed metering is not accurate, seed rate being higher than required; but this is a desirable feature of dry sown paddy, since under dry conditions, thicker sowing considerably reduces the effects of weed competition. A four-row version for use with a 2-wheel tractor has also been built and found to be suitable.

Another locally developed seeder has been used successfully for the dry seeding of rice. It uses the familiar fluted roll seed metering device except that each row has its own hopper and metering mechanism, and transmission is eliminated by driving the fluted roller directly from the ground wheels on one shaft. Spacing is adjustable and a variety of crops can be seeded using different rollers. This seeder has been used successfully with groundnut, onions, chillies, beans and sesame in addition to rice. It was developed chiefly in response to the needs of relay planting and mixed cropping and can be used in three versions, viz: manual 2-row, 2-wheel tractor 4-row, and 4-wheel tractor 8-row arrangements.

The negligible importance of precision seeding of rice is best illustrated in a simple seeder developed at IRRI using empty oil cans and wire attached to an animal-drawn toothed harrow ("lithaw"). This simple device has produced a very satisfactory stand of rice this season.

ROW SEEDING UNDER LOWLAND CONDITIONS

The two major problems encountered in the design of a seeder for lowland conditions are first, having to work in mud, and second, having to use sprouted seed which is wet and has a tendency to cling together by the entanglement of the roots of the germinating seeds. Carefully controlled germination of seed is an essential pre-requisite if any mechanical device is to be used. A seeding machine for manual operation must also be designed to be pulled and not pushed, since pulling is easier in muddy conditions.

The row seeding of rice under wet conditions was first popularized among farmers in Ceylon in 1955, and a simple machine, devised for the purpose by Johnpulle (3), was used. Made almost completely of G.I. sheet, this machine consists of a skid with four or six tubes attached to it. The tubes ended in a hopper for seed. The operator pulls the seeder across the mud with a handle, and simultaneously agitates the sprouted seed in the hopper by hand. The machine is cheap, easy to use, and the rate of seeding is not too slow to effect timeliness under conditions of small land holdings. Since then, the popularity of row seeding has encouraged many inventors resulting in as many as fifteen different seeding devices being available for testing by 1959 (4). The success of the Johnpulle seeder and its almost exclusive use in the row-seeding of rice in Ceylon today, gives an impression that perhaps the

degree of complexity of a wet paddy seeder is in inverse proportion to its degree of success!

The development of the IRRI 8-row seeder (6) is a logical extension of the simple Johnpulle seeder. It has a simple but effective metering mechanism, is light and has a high working capacity. It is being manufactured and marketed in the Philippines by three manufacturers and is being tested ane evaluated elsewhere. Seed metering is accomplished in two stages - the first by a fluted roller with a brush cut-off, and the second stage allows excess seed to "overflow" from guide chutes that lead to the seed tubes. There is a single wheel to drive the mechanism and also to transport the seeder along narrow levees. With its capacity of 1½ hectare per day and low cost ($50.00), it appears to provide a cheap and technically sound alternative to transplanting.

The Designs and Testing Center, Maha Iluppallama, Ceylon, has developed a seeder using a modified cup-feed mechanism in order to eliminate long seed tubes. A disc with vanes replaces the conventional cups and the hopper straddles four rows. Ground wheels at either end of the hopper drive the metering discs which are fixed to the same axle. Seeding rate is determined by the number of vanes on each disc. The machine lends itself to fabrication by small village shops and works very satisfactorily.

More precision in metering and a variable seed rate are desirable features in a wetland seeder for rice. Low cost and ease of fabrication are of major importance while increasing of capacity (ha/hr) is secondary. Work with these objectives in mind is being conducted at IRRI (7) and elsewhere.

TRANSPLANTING

Transplanting in standing water is still the most widespread technique for stand establishment throughout Asia, in spite of the high peak labor requirement. It has the advantages of requiring less precision in land preparation than direct seeding, creating conditions for better weed control and management, of regularizing plant spacing and above all, saving up to 20 days of the occupancy of the field by the crop. The time spent in the nursery gives more time to prepare the field efficiently, and, in the increasing necessity for relay cropping and multiple cropping, provides extra time for the growing of more crops per year.

Manual transplanting is laborious and demands a high labor requirement for only a few days per season. The mechanization of transplanting has been an attractive proposition to agricultural engineers for many years, particularly in Japan and China. A simple wooden transplanting machine, invented by Lin Tichian, a research worker in South China, was demonstrated in India and Ceylon circa 1959 and was subsequently tested locally (9). The machine plants five hills each time a lever is moved. The lever is part of a linkage that operates five pairs of fingers that pick up seedlings from a box and plants them in the mud. The lever, through a pawl and ratchet, also actuates a cylindrical cam which moves the seedling box gradually to and fro so that seedlings are removed from all parts of the box. Other similar machines and mechanisms have been developed in Japan and elsewhere. Japan, in particular, is producing a number of transplanting machines of very sophisticated design. Several

planting mechanisms are being used, and development has even included hydraulically actuated fingers -- this produces a limited pressure on the seedling handled, to minimize seedling damage from fingers. There are self-propelled models as well as those mounted on two-wheel power tillers and driven from the PTO. Taiwan also produces similar machines. In nearly every case, although the machine itself was efficient, the purpose of mechanization was defeated because a high labor input was necessary to prepare seedlings for the machines and to arrange them in the magazines or seedling boxes. The figures provided below by Ezaki for Japan illustrate this clearly (8).

Table 1. Labor requirement for transplanting rice in Japan. (Ezaki)

Transplanting by hand		Transplanting by machine	
Operation	Man-hours per ha.	Operation	Man-hours per ha.
Removal from nursery	100	Nursery and loading of machine	120 to 220
Transplanting	120	Transplanting	10 to 30

Development of transplanting machines in Japan is oriented towards reducing the labor required to uproot and prepare seedlings for mechanical transplanting. The basis of machine design has to change in order to accommodate a simple system of seedling management. One system being explored is the growing of seedlings in shallow aluminum trays where each row of seedlings is separated by a dividing strip of aluminum. When ready for transplanting, the strips are removed, leaving rows of seedlings growing in square-section long blocks of soil. These are transferred to the machine, which feeds them on to a knife that cuts off a cube of soil at a time and directs the soil block with seedling attached into the mud below. Other developments are modifications of similar procedures.

Viewing the performance of mechanical transplanting machines developed so far, one is inclined to feel that the best solution to mechanical transplanting is to give up transplanting rice! But under certain conditions the advantages of transplanting cannot be overlooked, and the interest in mechanizing the operation needs to be kept alive. In this connection, it is worth considering a technique of transplanting which, although not strictly mechanical, does save labor considerably - the "paper nursery" technique (10).

The paper nursery technique, developed in Japan by Koike and his associates, uses rayon thread sewn on to rough paper as a means of holding seedlings at regular spacing for planting in the field. The technique uses a total of 40 man-hours per hectare, inclusive of the removal of plants from the nursery, and saves 20 days of field occupancy of the rice crop. A highland nursery is used to raise seedlings and unsprouted dry seeds are sown in it.

Seeds are sown in the folds of an accordion-pleated paper pressed into the nursery bed. Two lengths of rayon thread 100 meters long are previously stitched in a specific pattern on the paper, so that the seedlings have their roots entangled in the thread. When seedlings are 20 days old, the paper has partially decomposed and the entire "nursery" can be lifted from the bed and transported into the field. As the thread is unravelled it carries with it a seedling or two spaced four to six inches apart. Ten to twelve threads can be unravelled at one time by one man who walks backwards and lays the unravelled threads on the prepared mud surface, now drained of water. Water is withheld for a week, by which time the plants are erect and occupy evenly spaced rows in the field. Experiments over four seasons with H-4 and IR8 varieties in Ceylon showed no tendency to lodge more, or yield less than manually transplanted treatments.

The specific method used to establish a stand of rice will depend on the conditions of soil, water control, cropping scheme, etc., prevailing. The mechanization of these various methods is possible under land holding conditions prevailing over most of Asia. This paper has reviewed the possible methods, and the efforts being made to make the operations more economical and efficient.

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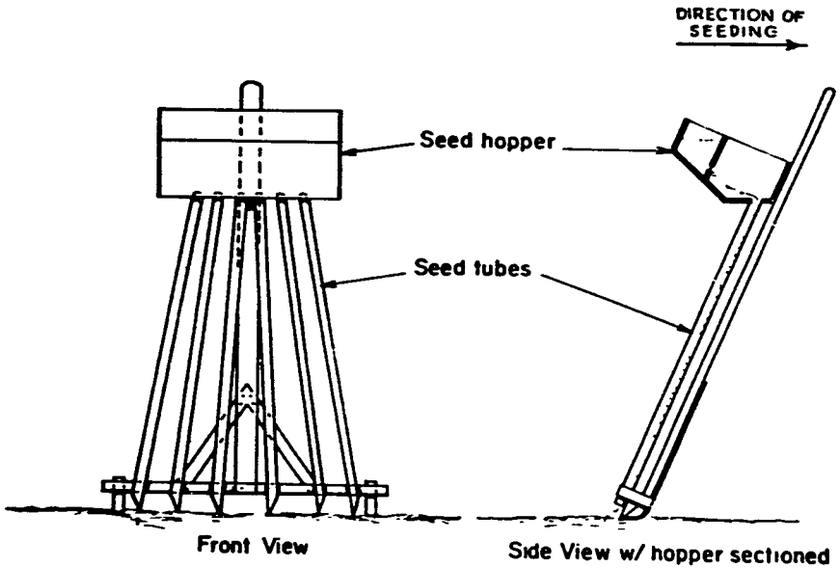

Fig. 1. CEYLON PORTABLE 6-ROW SEEDER
(Johnpulle seeder)

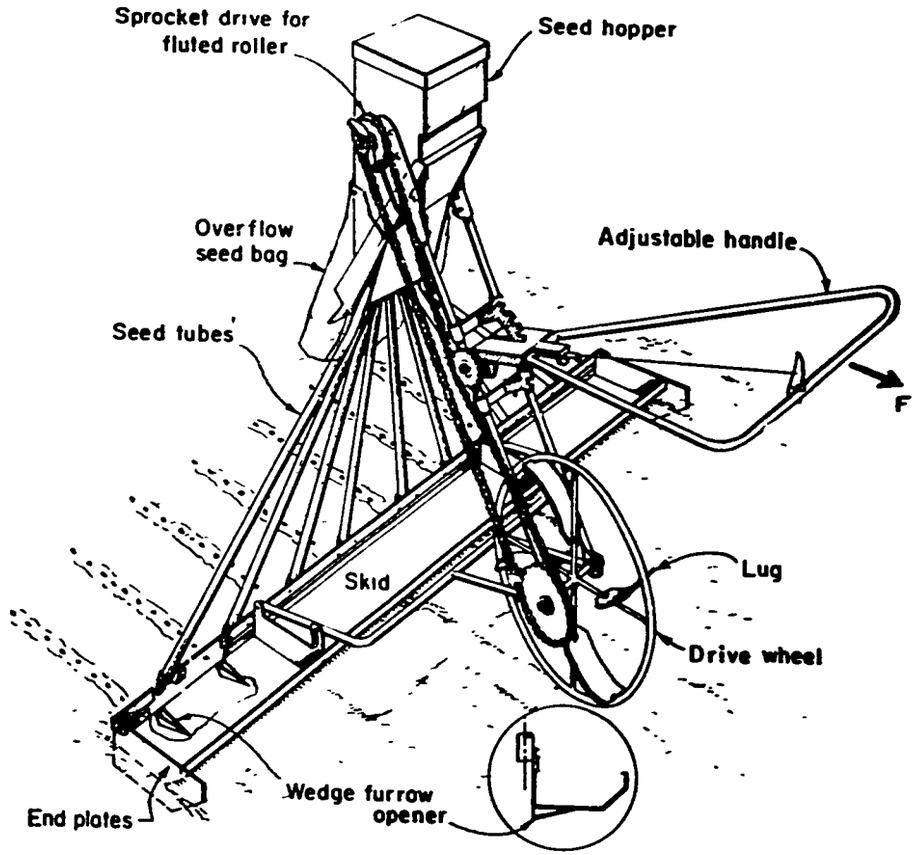

Fig 2 IRRI ROW SEEDER FOR PRE-GERMINATED PADDY

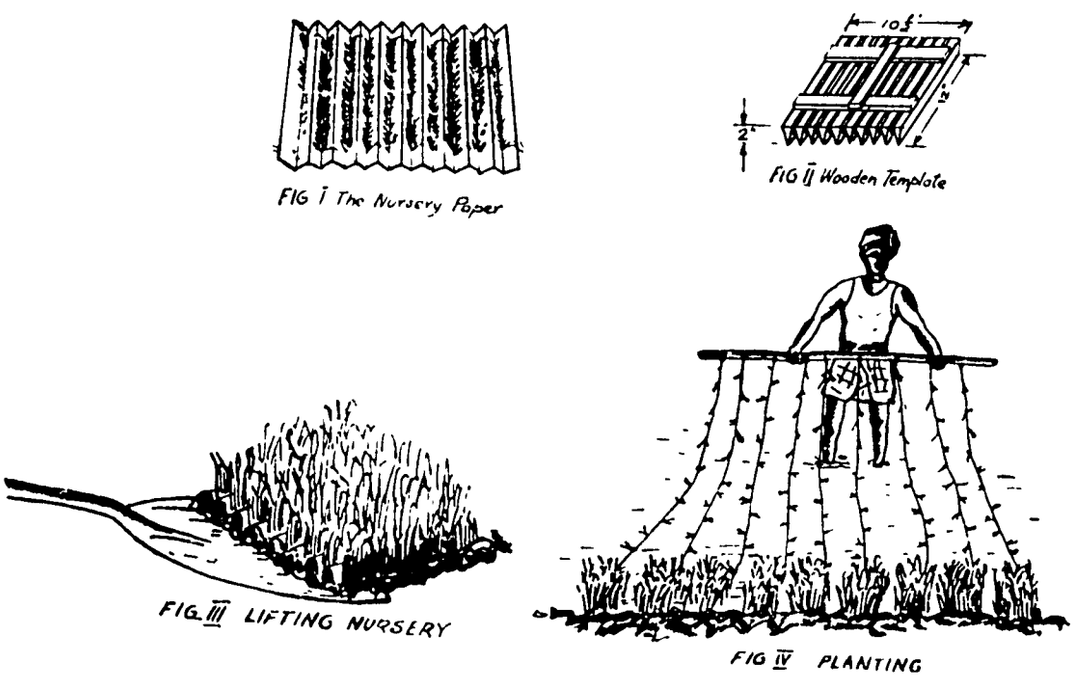

Fig. 3. Paper nursery technique