EARLY CROP ESTABLISHMENT OF RAINFED LOWLAND RICE BY SLIT SEEDING[1]

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ABSTRACT

The uncertainty of rains at the onset of wet season (WS) and the drought risk involved hinder growing more than one rainfed lwoland rice crop per year. Establishing transplanted rice well into the WS leaves insufficient moisture in the soil for subsequent crop. Rice establishment early in the season gives the farmer better opportunities to grow a crop after rice.

An experiment was conducted starting in 1993 to evaluate dry seeding of rice through slit soil seeding. It is done utilizing the vertical metering slit seeder for conserving soil moisture coming from the first rains in the early WS to sustain germination and establishment of the seedings at least until the succeeding rains under the rainfed lowland (RL) environment. The treatment consisted of slit-seeding the PSBRc 14 into the tilled and nontilled plots at 100 kg/ha and at depths of <10 mm (shallow seeding) and 60-70 mm (deep seeding). The control treatment was broadcast seeded on tilled soil and harrowed tocover the seeds.

The superior crop establishment observed in 1995 WS experiment on nontilled, slit-seeded plots confirmed the results observed in 1993 WS and 1994 WS experiments. Emergence in deep seeding was not significantly different from shallow seeding in nontilled plots giving an average yield of 2.1 t/ha in all slit-seeded plots. This offers an advantage of reduced energy input in nontilled shallow seeding. However, heavy weed infestation has to be addressed at the early stage of rice in nontilled soil to get the full advantage from slit seeding. The consistently better crop establishment observed in slit seeding over that of broadcast seeding in the WS of 1993, 1994 and 1995 also demonstrates that the slit seeding technology can be adopted with confidence in the rainfed lowland field condition to reduce the risks involved in broadcast seeding.

INTRODUCTION

Good crop establishment of rice in rows needs reliable mechanical seeders. Common deficiencies of seeders, such as unreliable seed metering, seed breakage and clogging at points along the seed delivery path from the hopper to the soil were avoided in the design of the VMSS used in the experiments. Economy of design for acceptability by farmers was also a major factor considered. A major technical consideration, however, was the functional performance of the seeder. The VMSS must therefore, demonstrate certain

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advantages over the farmers' normal practice of dry seeding to establish an early RL rice crop. The advantages might be reduction of risk from drought and increase in cropping intensity apart from increase in yields to justify the investment in the machine and the extra labor in machine seeding.

The early crop establishment experiments

In experiments conducted in small plots during the early 1992 WS, Moody and Lubigan (1993) found that use of the VMSS gave superior crop stand over the farmer's DSR method by broadcast. The experiments needed verification in bigger plots under farmer's field conditions.

Field experiments on early crop establishment were conducted at the Tarlac Rainfed Lowland Rice Research Consortium site in Victoria, Tarlac, Philippines during the 1993, 1994 and 1995 WS. The following objectives were pursued:

1. Evaluate the performance of the VMSS in establishing rice at the earliest opportunity during the WS under different tillage and depth of seeding.

2. Compare the slit seeding with the farmers' broadcast seeding in dry soil.

METHODOLOGY

DSR equipment

A two-row slit seeder with vertical metering device pulled by a hand tractor was used in early WS crop establishment of rice (Fig. 1). Each row of the VMSS consisted of seed hopper, metering device, ground drive wheel, seed delivery tube, and soil slitting device. The seeder had a hitch-pin attachment to a power tiller. It could be adapted for pulling by draft-animal.

The seed metering device consisted of a disc plate vertically positioned inside the hopper. It had 16 peripheral holes sized for picking up 2-3 medium-sized (5-7 mm) rice seeds. As the seeder moved forward, the metering plate, driven by the ground wheel, rotated about the horizontal axis and picked up rice seeds which were then discharged into an elevated port leading to the seed tube. A protective wall between the stationary and the moving seed plates prevented the grinding action on the seeds, minimizing seed damage. The metered seeds passed through a tube located behind the shank. This shank had a tine at the bottom end for soil penetration. Actual seed discharge in the plots was 98% of the calibration (100 kg ha^{-1}).

The shank with a frontal blade made a 3-mm wide and continuous soil slit into which the metered seeds were deposited in rows just above the bottom line traced by the tine. A depth gage wheel controlled the depth of deposition of seeding. The tine provided a 3-mm clearance between the bottom of the slit and the seed position in the soil. The 3-mm slit minimized the escape of moisture, yet provided sufficient aeration to enhance seed germination. In case of light rains or showers, water could easily seep into the seed position where moisture was much needed.

Based on previous field tests of the VMSS, the tine was shortened (Fig. 2). A wing guide at each side of the seed tube discharge end was installed to prevent entanglement of the shank with weed residues, and also the clogging of the discharge hole. These design features allowed the weeds to be deflected sideways permitting self-clearing of the shank and tine assembly.

Seeding dates

The seeding dates for the three WS experiments varied according to the incidence and amount of rainfall at the beginning of the WS which determined the workability of the soil. These dates were June 6, 1993, June 9 1994 and May 24, 1995. These dates were ahead of those when farmers in the area would normally broadcast seed their fields as the reliability of the rainfall was considered low.

Experimental design

A two-factor (tillage and depth of seeding) experiment in randomized complete block design with four replications was conducted in 1993 WS and repeated in the 1994, and 1995 WS. The plot size was 7 m x 7 m in 1993 and 1994 trials and 7.5 m x 11.5 m in the 1995 trial. Seeding rate was 100 kg ha^{-1}. Rc14, a recommended RL variety in the Philippines, was used in 1994 and 1995. However, PSB Rc10, a lowland rice variety was used in 1993.

In the first experiment in 1993 WS, slit seeding at depths of 0, 30 and 70 mm in tilled and nontilled soils was tested. Control plots were represented by the adjacent farmer's field. In the 1994 WS and 1995 WS experiments, control plots were by broadcast tilled (simulating farmers' practice). Treatment plots consisted of tilled and nontilled soil with seeding depths of shallow (0-10 mm) and deep (60-70 mm).

The following treatments were used: (1) tilled soil-shallow slit-seeded (0-10 mm); (2) tilled soil-deep slit seeded (60-70 mm); (3) non-tilled-shallow slit seeded (0-10 mm); (4) non-tilled-deep slit seeded (60-70 mm); and (5) control (farmers' practice of broadcast seeding on animal-plowed and harrowed field then covering the seeds by harrowing).

Tillage started as soon as the soil strength was reduced by total rainfall. All the plots were weedy fallow since the previous TPR crop was harvested. Animals, including cows, buffalos and goats, were allowed to graze freely on the land such that only a few weed species, mostly broadleaved, had remained until the experiments started. Tilled plots were prepared by one plowing and two rotary tillings immediately before slit seeding. A rotary tiller, powered by a 6.5-hp hand tractor, was used for tillage.

The VMSS was pulled by a 6.5-hp hand tractor. Depths of seeding were set at 5 mm for the shallow and 65 mm for the deep placements.

Fertilizer was applied by band dressing at the rates of 120-30-30 kg NPK ha^{-1} in three equal splits (at 7 DAS, at maximum tillering and at booting). Weeds were controlled by manual pulling. Integrated pest management was practiced during the cropping period. All the plots were harvested manually.

RESULTS AND DISCUSSION

Crop establishment under early WS rainfall patterns at Victoria, Tarlac

The rainfall patterns at the experimental site were not the same during the early WS in 1993, 1994 and 1995 (Fig. 3). The June 1993 rainfall had four peaks ranging from 40 to 120 mm rain. The June 1994 rainfall was evenly distributed but the amount ranged only from about 5 to 35 mm. During the last week of May up to the first week of June 1995, rainfall ranged from about 3 mm to 87 mm. The accumulated rainfall during 5 days before seeding in 1993 (June 6), 1994 (June 8), 1995 (May 24) were 78, 57 and 107 mm, respectively. In 1995, a 17-day dry period occurred between 16 DAS until harvest.

In all the three early WS rainfall patterns, the slit-seeded rice crops were able to establish, in spite of drought periods in 1993 and 1995 lasting 12 days and 17 days, respectively. In 1993 however, the crop in the broadcast-seeded plots failed to establish because of the insufficient rainfall (total of only 18 mm) during the period, 0-5 days after emergence (DAE). The thin soil layer which covered the broadcast seeds perhaps did not give adequate protection from solar radiation which averaged 20 MJ m^{-2} during the rainless period and with two peaks at 23 and 21 MJ m^{-2} occurring in two alternate days (Fig. 3). The lower emergence in the shallow slit-seeded may also be due to inadequate heat protection and low moisture in the thin soil layer. In 1994, the soil had always plant-available moisture from sufficient and evenly distributed rainfall. In 1995, the prolonged dry period (9-25 DAE) affected the crop growth and eventually the yield. Apparently, these three distinct patterns of early WS rainfall were tolerable for the early crop establishment by slit seeding. The slit seeding technique might have given the seeds or seedlings adequate protection from heat and low moisture stresses.

Emergence was also low in the tilled plots which were slit-seeded in the 1993 experiment (Fig. 4). In contrast, the nontilled, shallow slit-seeded plots had even higher, although the difference was insignificant at 5% level, than the tilled, deep slit-seeded plots, indicating there was plant-available moisture in the undisturbed soil.

Soil moisture conservation by slit seeding

The slit-seeded rice in both tilled and nontilled soils were established in all the three WS experiments. There was sufficient plant-available moisture to sustain germination and full development of the radicle and the coleoptile due to the minimum disturbance of the bare surface soil which prevented fast evaporation rate. Observation in the arid areas, such as in parts of New Zealand, confirm this observation with the use of the inverted-T seeder (Choudhary and Aban 1986). In that seeder, the soil opener had a projection at each side which slitted the soil horizontally at the bottom of the cut where the seed was deposited. The horizontal slit of the inverted-T opener aimed at conserving rainwater.

Only in the 1993 experiment did the advantage of slit seeding over broadcast seeding became evident. The control technique which was the farmer's method in the area failed to establish under the earliest seeding date possible for the WS slit seeding. As a common practice, the farmer would delay seeding until rainfall has accumulated to soften the soil for easy land preparation and wait some more days until the rainfall can assure crop establishment. The 1993 experiment demonstrated that this was the sensible method if the farmer uses the broadcast seeding technology. The experiment also demonstrated however, that under the same circumstances, a rice crop can be established and give a good yield if slit seeding technology was to be adopted.

It is important to consider the early WS rainfall pattern to determine the critical period, i.e., the first 15 DAS to determine the survival of the seedlings. The experiment however, did not firmly establish that 15 DAS was the critical period. It only demonstrated that the crop could survive a 15-day period of almost no rain and high solar radiation (ranging from 17 to 23 mJ/m^2) using the slit seeding technique when the usual farmer's broadcast method failed.

In 1995 WS experiment, the nontilled plots had about twice the weed biomass than the tilled plots, indicating the importance of tillage in weed control and therefore, in crop establishment and maintenance to attain optimum yields. This phenomenon has been shown in the studies of Hundal and de Datta (1982), Pasuquin and Lantin (1995) and Moody et al (1993). Labor expenses for weeding was much higher for the nontilled plots than for the tilled plots. Therefore, this is a deterrent for the farmers' adoption of the nontilled slit seeding which is part of the technology package to achieve comparative advantage. The decision of whether to till the soil will be based on the benefit from the yield increase by tilling versus the cost of performing it or of doing the pre-WS soil management operations to eliminate tillage during the crop establishment period. Additionally, the benefits would be balanced against the costs of performing weed control which needs further development as part of a future technology package in crop establishment in drought prone RL ecosystem.

Effect of tillage and depth of seeding on seedling emergence

Emergence in nontilled soil was better when seeds were slit-seeded shallow than when slit-seeded deep. This observation was consistent for all the three years of experiment (Fig. 4) However, in tilled soil the reverse was true, that is, the deep slit-seeded plots tended to have higher seedling emergence than the shallow slit-seeded plots, except in 1994 when the germinating seeds did not suffer soil moisture stress. Seed emergence count from the seeding rate of 100 kg ha^{-1} in nontilled soil was 88% during 1994 compared to 64% during 1993. We attribute the higher seed emergence to the timely rains which occurred during the period from seeding to germination in 1994. We attribute the lower seed emergence in tilled than in nontilled soil to the inadequate soil-seed contact in the tilled soil due to big clods and to the lack of contact of the seed with a firm soil. In 1995, the early WS rainfall conditions were favorable such that emergence did not vary between treatments. Even the broadcast-seeded plots had high seedling emergence.

Deep slit seeding gave no agronomic advantage over shallow slit seeding in any the three early WS experiments. Shallow slit seeding however, offers the advantage of lower energy requirement for seeding. For a given power unit, the number of rows could be increased, thus increasing the seeding capacity and productivity of labor.

Weed growth

Data for weed dry matter were not collected during the 1993 and 1994. However, ocular observations during the establishment periods in 1993 and 1994 WS indicated more weed density in nonntilled than in tilled plots. This was verified by the actual measurements of weed dry matter in 1995 wherein the nontilled plots had the heaviest weed infestation. Although the data indicate that the results were not conclusive, severe weed problems often occur in nontilled soils (Bligh,1988, Naka, 1981). The observation is similar to the findings of Pasuquin and Lantin (1995) regarding the higher weed population in a weedy fallow than in a tilled soil mulch during the pre-WS tillage experiment. The favorable soil moisture condition during crop establishment gave the weeds competitive advantage over the rice seedlings.

The advantage of high seed emergence in the slit-seeded, nontilled plots over the tilled plots was offset by heavy weed infestation in the nontilled plots. Hand weeding, especially the pulling of *Echinocloa colona* and the broadleaved weeds also uprooted some of the rice seedlings within the root zone of the weeds. Nevertheless, the yields from the nontilled plots were not significantly different from those in other treatment plots.

CONCLUSION

The early WS rainfall patterns of 1993, 1994 and 1995 at the experimental site in Victoria, Tarlac were not similar. The rice crops which we tried to establish as soon as the first rains of the WS were at risk of not being established due to the incidence of drought during the critical period after seeding.

Tilled plots gave higher yields than nontilled plots in 1993, incidating some advantage of tillage in crop establishment during the early WS. However, there was no significant difference in yield between slit-seeded in tilled and in nontilled soil in 1994 when water was not limiting. Similarly, since there was apparently no drought stress experienced by the seedlings during the first 15 DAS in 1995, the crop was well established. The next 20-day drought period however, was devastating to the crop resulting in low yields in 1995 compared to those in 1993 and 1994 (Fig. 5). While the plot yields in 1993 and 1994 ranged from 3.5 to 4.9 Mg ha^{-1}, except for the zero yield for broadcast-seeded plots in 1993, those in 1995 ranged only from 1.5 to 2.3 Mg ha^{-1}, across all treatments.

There are however, certain soil management factors which may be integrated with the slit seeding technology to attain the advantage of less weed and effective soil moisture conservation. Integrating the soil mulching approach with the slit seeding technology will give additional advantages worth verifying by field experiments. Pre-WS soil management such as soil mulching by shallow tillage after harvesting the crop preceding the early WS crop establishment should be integrated with slit seeding.

The slit seeding technique presented superiority over broadcast seeding when drought conditions immediately follows seeding. The observation however, was only in 1993 WS and verification is still needed. Some soil moisture conservation feature, such as in the inverted-T seeder, may be adapted to the slit seeder.

Weed control has remained a problem in DSR. Row seeding as in the use of the slit seeder may only be marginally advantageous over broadcast seeding unless a suitable dryland weeder is developed along with the crop establishment system package. An effective and low-cost animal or power-driven inter-row cultivator for DSR is needed.

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Fig. 1. Vertical metering slit seeder in operating mode.

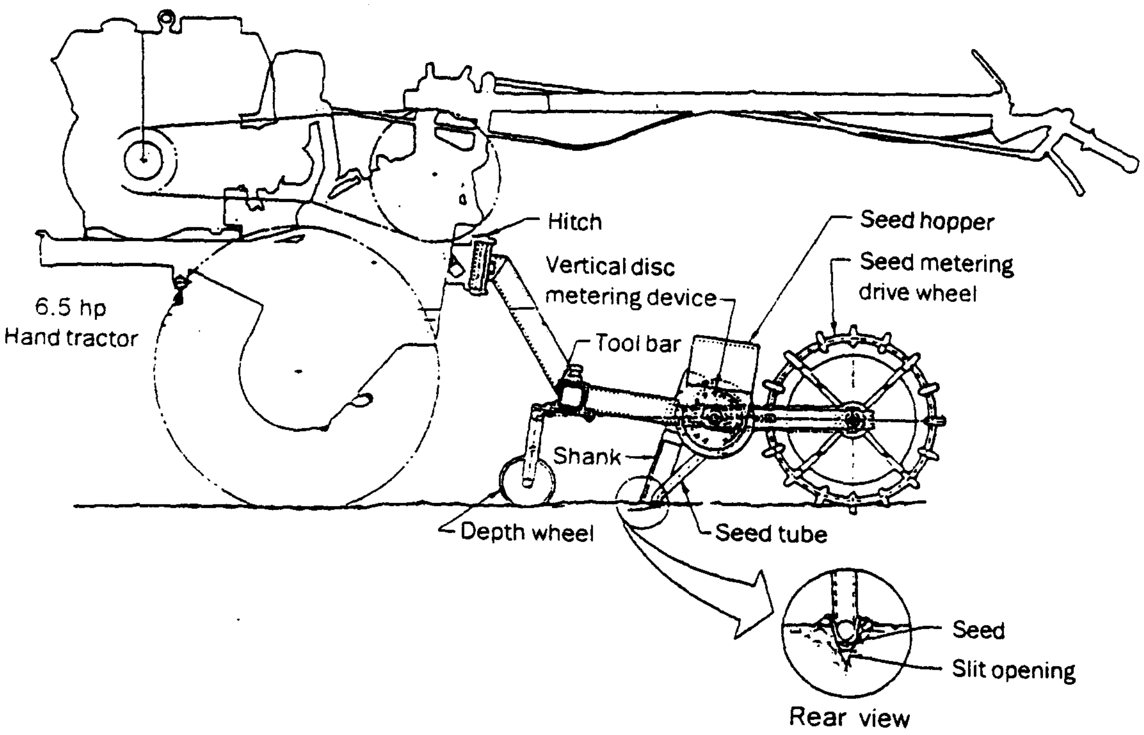

Fig. 2. Modification of the tine and provision of wing to eliminate weed residue accumulation and clogging of the seed discharge hole.

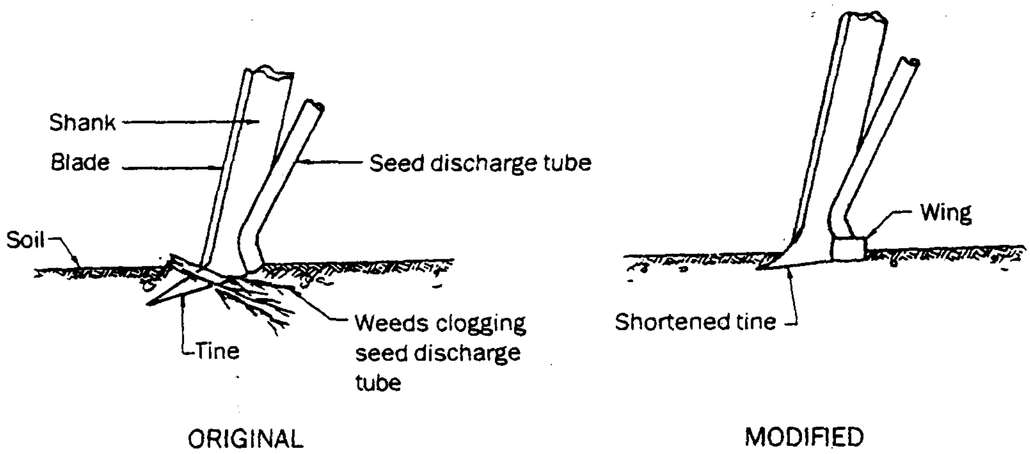

Fig. 3. Daily rainfall and solar radiation during the early WS of 1993 to 1995, Victoria, Tarlac, Philippines.

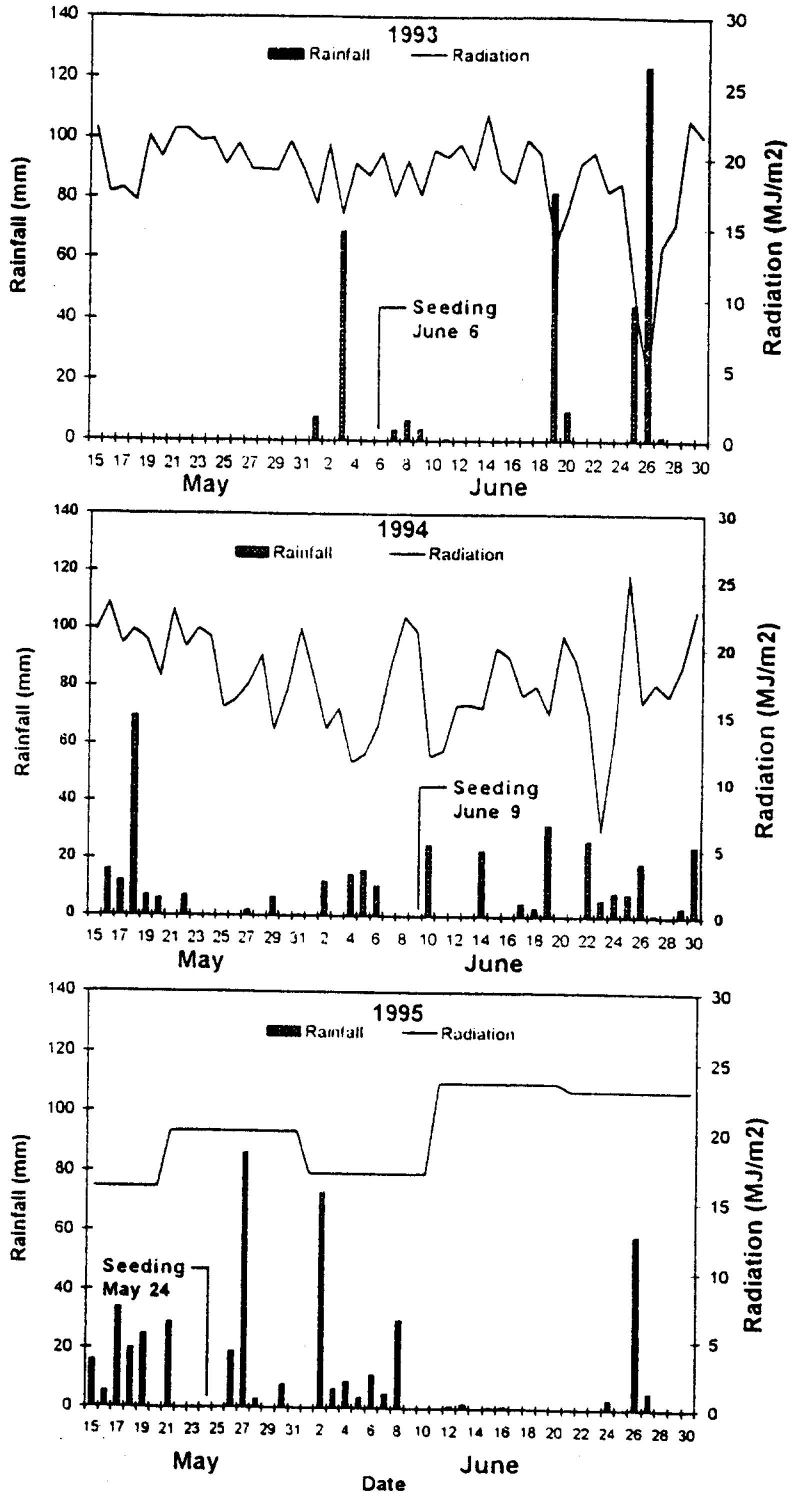

Fig. 4. Emergence of rice in broadcast seeded, slit seeded in tilled and nontilled plots, Victoria, Tarlac, Philippines, 1993-95.

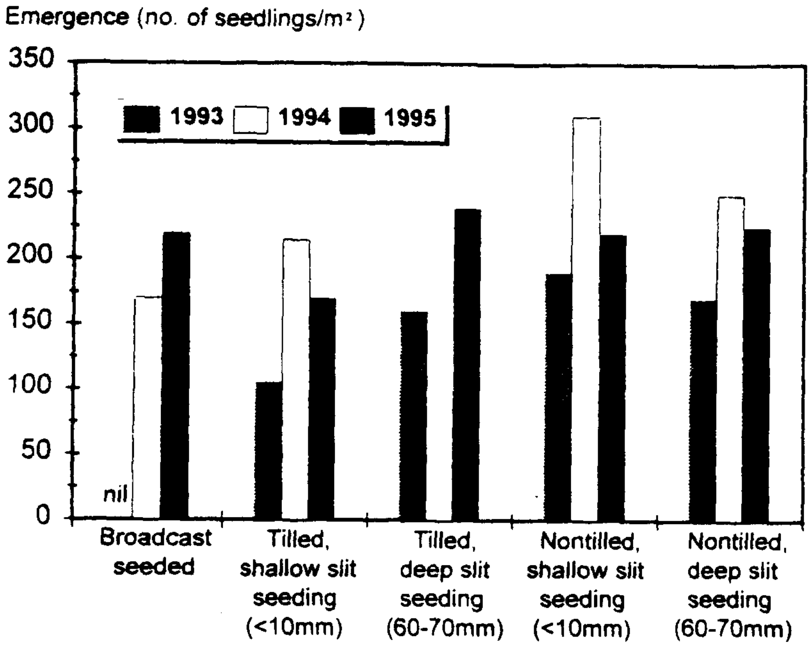

Fig. 5. Grain yields in broadcast seeded, slit seeded in tilled and nontilled, Victoria, Tarlac, Philippines, 1993-95.