EMERGENCE AND COMPETITION OF 'POLLA' [*Sacciolepis interrupta* (Willd.) Stapf.] IN SEMI-DRY RICE

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**Emergence and competition of 'Polla' [*Sacciolepis interrupta* (Willd.) Stapf.] in semi-dry rice**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled **"Emergence and competition of 'Polla' [*Sacciolepis interrupta* (Willd.) Stapf.] in semi-dry rice"** is a record of research work done independently by **Ms.Renu, S.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms.Renu, S.,** a candidate for the degree of **Master of Science in Agriculture** with major in **Agronomy**, agree that the thesis entitled **"Emergence and competition of 'Polla' [*Sacciolepis interrupta* (Willd.) Stapf.] in semi-dry rice"** may be submitted by Ms.Renu, S., in partial fulfilment of the requirement for the degree.

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INTRODUCTION

INTRODUCTION

Weed control is the most expensive operation in semi-dry rice culture that is widely practiced during the first crop season of Kerala. In Kerala, traditional methods of weeding have become very costly due to high wages and shortage of labour. Herbicides are becoming popular in many parts of Kerala. However, the weed control strategy should be based on socio-economic and ecological considerations. Continuous use of herbicides may cause ecological imbalance and lead to weed shifts and herbicide resistance in weeds.

Integrated weed management (IWM) is an urgent requirement to minimise the undesirable effects. Integrated weed management is an approach in which principles, practices, methods, materials and strategies are chosen to control weeds so as to keep the undesirable results minimum. Various preventive, cultural, physical, chemical and biological methods should be rationally integrated to achieve the desired level of weed control. It is the better management of the crop and weed that is needed and not a clean crop. However, for chalking out an efficient weed management strategy for a particular crop situation, various aspects of weed phenology, weed physiology and the nature of weed crop interference of at least the major weeds must be known.

Sacciolepis interrupta (Willd.) Stapf. is reported as a serious weed of semi-dry rice in Kerala (AICRP-WC, 1992; Thomas *et al.*, 1997). The occurrence of *Sacciolepis interrupta* was not reported from wet seeded rice or transplanted rice or during the second crop season (*Mundakan*), which shows that the weed is endemic to *Viruppu* season (early *Kharif*), especially in the dry seeded crop. It enjoys the ecological situations associated with semi-dry rice, where rice is sown broadcast/drilled immediately after the receipt of pre-monsoon rains and the crop is raised as a rainfed rice for the initial 30-45 days, till the field is flooded due to south west monsoon. The problem of *Sacciolepis interrupta* assumes significance as more and more farmers resort to dry seeding mainly because of the uncertainity of receipt of rains in time and also to avoid the hassles of transplanting.

The success of semi-dry crop depends on the receipt of well distributed pre-monsoon showers and the number of early ploughings given. With the early ploughings all the weeds would sprout which would be destroyed by subsequent ploughing. If early showers fail and preparation of land is done during a short interval of time, weeds may overgrow and smother the crop.

In earlier days, usually 6 to 7 ploughings were given at intervals, as and when moisture conditions permit (Sahadevan, 1966). However, with the advent of tractors and heavy iron ploughs this practice became extinct. Moreover, bullock ploughing is not economical and availability is also less. Consequently farmers have reduced the number of ploughings. In the traditional method of land preparation, the principle of stale seed bed and depletion of weed seed bank is inherent in it. Experience shows that *Sacciolepis*, the major weed of semi-dry crop is amenable to such a treatment.

With the above considerations in mind, an investigation on the emergence and competition of *Sacciolepis interrupta* (Willd.) Stapf. in semi-dry rice was undertaken during 1999 at Agricultural Research Station, Mannuthy.

The main objectives of the study were:

1. To determine the emergence pattern of *Sacciolepis interrupta* (Willd.) Stapf. and its relationship with temperature and rainfall.
2. To estimate the losses caused by *Sacciolepis interrupta*.
3. To test the feasibility of stale seed bed technique for the management of the weed.
4. To work out the economics of various treatments.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Sacciolepis interrupta (Willd.) Stapf. is a serious weed of semi-dry rice in Kerala (AICRP-WC, 1992; Thomas *et al.*, 1997; Thomas and Abraham, 1998). The occurrence of *Sacciolepis interrupta* has not been reported from wet seeded rice or transplanted rice in Kerala. Reported works on the ecology and management of *Sacciolepis* are also limited.

A brief review of the various aspects of weed problems in semi-dry rice such as crop-weed competition, weed seed germination, dormancy and effect of stale seed bed on weed control with special reference to *Sacciolepis interrupta* is attempted in this chapter.

The review is made under the following heads,

2.1 Weed spectrum in semi-dry rice
2.2 Characterisation of *Sacciolepis interrupta*
2.3 Emergence of weeds
2.4 Crop-weed competition in rice
2.4.1 Critical period of crop-weed competition
2.4.2 Growth and yield attributes of rice affected by weed competition
2.4.3 Yield reduction due to weeds
2.4.4 Nutrient drain by weeds
2.4.5 Nutrient uptake by rice and competition
2.5 Management of *Sacciolepis interrupta*

2.1 Weed spectrum in semi-dry rice

Weed species in rice vary with the soil, system of rice culture, water management, fertility level and weed control practices. Information on weed flora in rice helps in formulating weed control methods.

About 350 species from more than 150 genera and 60 plant families have been reported as weeds in rice (Barret and Seaman, 1980). Smith (1983) observed Poaceae as the most important family accounting for more than 80 species of weeds in rice. Grasses and sedges predominate the weed flora of semi-dry rice (Jayasree, 1987; Palaikudy, 1989; Suja, 1989). Most prominent among the grasses are *Isachne miliaceae, Sacciolepis interrupta* and *Echinochloa colona*.

According to Varughese (1996), *Isachne miliaceae, Cyperus* sp., *Echinochloa colona, Sacciolepis interrupta, Oryza sativa* var. *fatua, Monochoria vaginalis* and *Ludwigia parviflora* were the major weeds in Onattukara region of Kerala during Kharif season. Thomas *et al.* (1997) reported the dominance of 40 weed species in semi-dry rice culture after a detailed survey of the central zone of Kerala where semi-dry system of rice culture is prevalent. The first ten weeds according to their ranking based on density and frequency were *Isachne miliaceae, Sacciolepis interrupta, Eriocaulon quinquangulare, Ludwigia perennis, Ammania baccifera, Cyperus albomarginatus, Dopatrium junceum, Eriocaulon cuspidatum, Echinochloa colona* and *Cyperus haspan*. Thomas and Abraham (1998) reported the predominance of grass weeds in semi-dry system and rated *Sacciolepis interrupta, Isachne miliaceae, Echinochloa colona* and *Echinochloa crusgalli* as the major weeds in semi-dry rice culture which requires special attention.

The occurrence of *Sacciolepis interrupta* as a weed has been reported from places outside Kerala also. A report from Assam, India, indicated the dominance of *Panicum walense, Sacciolepis interrupta, Cyperus pilosus* and *Scirpus juncoides* in wet seeded autumn rice (Barua and Gogo, 1993).

The major weeds reported in the irrigated rice of tropical Africa were *Cyperus* sp., *Paspalum* sp., *Cynodon dactylon, Ischaemum rugosum, Echinochloa* sp., *Sacciolepis* sp., *Sphenochlea zeylanica* and *Ipomoea* sp. (Ampong-Nyarko, 1996).

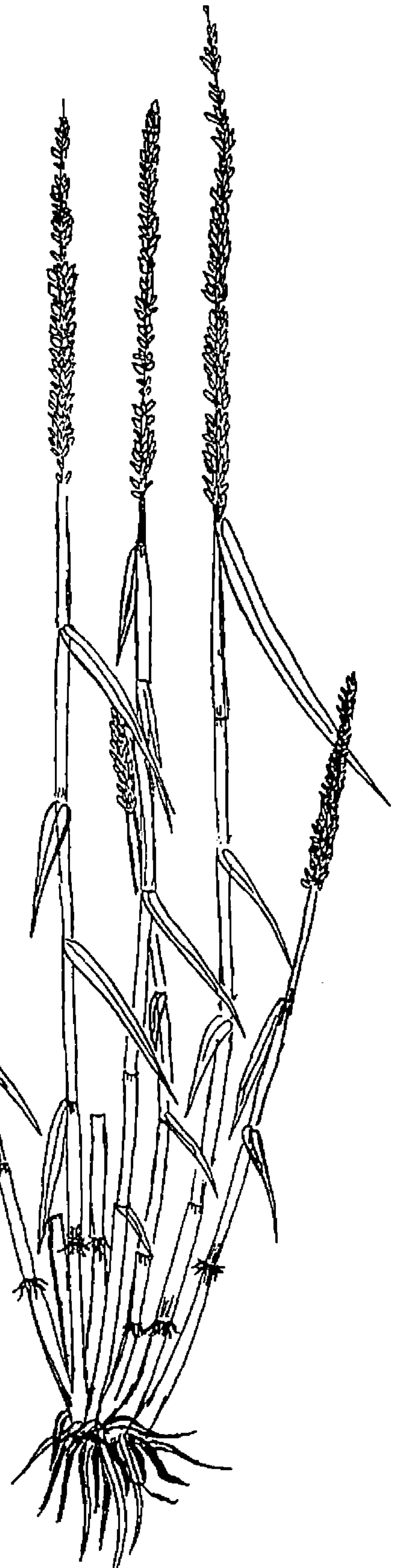

Fig.1. ***Sacciolepis interrupta*** **(Willd.) Stapf.**

Holm *et al.* (1979) reported that *Sacciolepis interrupta* (Willd.) Stapf is a principal weed in Nigeria and a common weed in Indonesia. They also reported it as existing as a weed in India, Bangladesh and Vietnam.

2.2 Characterisation of *Sacciolepis interrupta*

Gamble (1935) described the genus *Sacciolepis* Nash as perennial or sometimes annual herbs. He identified four species of *Sacciolepis* in southern India viz., *Sacciolepis interrupta, Sacciolepis indica, Sacciolepis myosuroides* and *Sacciolepis curvata.* Sreekumar and Nair (1991) reported three species of *Sacciolepis* in Kerala, *Sacciolepis indica* (Linn.) A., *Sacciolepis interrupta* (Willd.) Stapf. and *Sacciolepis myosuroides* (R.Br.) A. Camus. *Sacciolepis interrupta* could be distinguished from other species of *Sacciolepis* by its robust, spongy, floating culms and larger spikelets.

Sacciolepis interrupta (willd.) Stapf. is a tall grass with delicate stems which may reach 1.5-2.0 m height (Fig. 1). The culms are stout, spongy below, ascending from a creeping root stock. Because of its excessive sponginess, the weed is called *Polla* or *Pollakkala* in Malayalam, meaning a weed that is hollow. Leaves are elliptic-lanceolate, lanceolate or linear, glabrous, 4-35 cm x 0.3-1.4 cm, acute or acuminate and rounded or sub-cordate at base. The inflorescence is a spike like panicle, spiciform, interrupted and 3-35 cm long. The spikelets are densely packed in fascicles, many are imperfect and green or purplish. Spikelets are ovate-lanceolate or elliptic, 3-5 mm long. Occasionally, the whole plant is purple. The grass multiplies by seeds and rooted portions of stems (Tadulingam *et al.*, 1955; Manilal and Sivarajan, 1982; Vajravelu, 1990; Sreekumar and Nair, 1991; Thomas and Abraham, 1998).

2.3 Emergence of weeds

Studying the dormancy and germination behaviour of weed seeds in soil will help in the better management of the weed. The ability of the seeds to survive as a dormant tissue for a long time and germinate at the right time is a very important survival mechanism of weeds. Under optimal conditions, only a part of the seed germinate at one time and the rest remain as seed bank in the soil. It was also found that in the field, weed seeds alternatively lost and acquired dormancy and displayed seasonal rhythmic germinability during their periods of persistence in soil (Elgey and Duke, 1985).

Roberts and Dawkins (1967) found that in the absence of reseeding, weed seeds in the cultivated soil were reduced in number by about 25 per cent per year.

Light requirement is a principal means by which seed germination is restricted to the proximity of soil surface (Karssen, 1980).

Most weed species have a single temperature optimum for germination. Temperature strongly influenced the breaking of both primary and secondary dormancy, especially the onset and breaking of secondary dormancy (Elgey and Duke, 1985). They also found that allelochemicals like coumarin inhibited germination of seeds. Nitrite or gibberlic acid stimulated germination of *Lactusa sativa*. Nitrite broke dormancy of *Oryza sativa.*

Germination of seeds varied with depth of burial. Emergence of seeds of *Commelina benghalensis* were 19.5, 9.8, 2.5, 1.0 and 0.5 per cent for seeds buried at zero, two, four, six and eight centimetre depth respectively (Budd *et al.,* 1979)

Bhan (1983) observed that weed emergence was maximum at field capacity, but the emergence was reduced up to 15 cm submergence. Gill *et al.* (1985) reported that 5-6 cm standing water for four weeks significantly reduced seedling emergence of *Echinochloa crussgalli* than at 3 cm water depth.

According to Singh and Bhan (1986), maximum emergence of *Echinochloa crussgalli, Echinochloa colona, Cyperus iria* and *Eclipta alba* occurred during the first 45 DAT of rice.

Zimdahl *et al.* (1988) reported that 40-50 per cent of weed emergence occurred within 6 weeks of tillage in upland and low land rice soils. According to them, *Rotboellia cochinchinensis, Digitaria ciliaris* and *Eleusine indica* exhibit a peak of emergence early in the rainy season with subsequent small peaks linked with rainfall.

It was reported that emergence duration of barnyard grass varied with sowing date and increased as soil depth increased (Martinkova and Honek, 1993). In a later study, Martinkova and Honek (1995) found that germination of *Echinochloa crussgalli* following a short after ripening period was low (22%) as compared with prolonged after ripening (28.4 to 95.2%).

2.4 Crop-weed competition in rice

Weeds interfere with rice growth by competing for one or more growth limiting resources, such as light, nutrients and water; and weed competition is probably the most important factor limiting the yield of crops. Cereals are most sensitive to weed competition in their early stages of growth. Weed damage to crop varied with weed species, crop variety, duration and density of infestation of weeds, environmental factors and cultural practices (Smith, 1983).

Grassy weeds are most influential in reducing rice grain yield followed by broad leaf species and then by sedges (De Datta *et al.*, 1968). In general, grasses are the most dominant weeds during the early crop season, while sedges and broad leaf weeds dominate later in the season (Jiang, 1989).

2.4.1 Critical period of crop weed competition

Critical period of weed competition is that part in the life cycle of a crop plant wherein weeding results in highest economic returns.

In India, the entire weed competition impact occurred due to weeds left past the first 20 days after emergence (Zimdahl, 1980). The most critical period of weed competition with regard to grain and straw yield was 20 to 40 days after sowing (Sukumari, 1982). Critical period of crop-weed competition in upland rice was reported to be about 40 DAS by Varshney (1985). According to Sankaran and De Datta (1985), in upland rice the first 15 days after seeding rice seems to be the maximum period during which weeds can be tolerated without affecting the final yield.

The critical period of weed competition in upland drilled rice was initial 15 to 45 DAS according to the results of the trials conducted at the co-operating centres of the All India Co-ordinated Research Programme on Weed Control (Saraswat, 1989). Thomas and Abraham (1998) reported 15 to 45 days after sowing as the critical period in semi-dry rice system.

2.4.2 Growth and yield attributes of rice affected by weed competition

The presence of weeds affect the growth, dry matter production, yield attributes and yield of crop plants.

Palaikudy (1989) reported that high weed density and weed competition reduced the height of the crop. Excellent control of wrinkle grass with oxyfluorfen resulted in better plant height (Singh *et al.*, 1990). Better tillering was reported with effective weed control by Sudhakara and Nair (1986).

A majority of weeds i.e., about 56 per cent, belong to C_4 type. Under semi-dry condition, moisture stress occurs during early stage of crop and both C_4

and C_3 plants close their stomata partially. However, for the same amount of stomatal opening, uptake of CO_2 might be higher in C_4 weeds than in C_3 rice probably leading to higher growth rate in C_4 weeds (Bhargavi and Reddy, 1993).

Patel *et al.* (1985) reported that crop dry matter was negatively correlated with weed dry weight or weed density. Weed dry matter at harvest was highest for unweeded check resulting in grain yield reduction (Purushothaman *et al.*, 1988). Suja (1989) mentioned that severe weed competition and high weed density affected the crop growth and reduced the height and crop dry matter production. The dry matter production by the crop was higher in plots where a hand weeding or the pre-emergence herbicide was applied (Palaikudy, 1989). In general, rice dry matter yield would be reduced by 1 kg for every kilogram of weeds produced in the same area (Ampong-Nyarko and De Datta, 1991).

Yield attributing characters like number of panicles per m^2, spikelet per panicle and 1000 grain weight were lowest in the unweeded control; and suitable weed control methods significantly improved the yield attributes (Ravindran *et al.*, 1978). Crop plants under competitive stress produced fewer tillers, fewer panicle bearing tillers and also manifested smaller panicles, delayed flowering and increased plant height (Noda *et al.*, 1968).

Weed control treatments significantly increased the number of panicles per m^2 and filled grains per panicle compared to unweeded control (Kumar and Gautam, 1986). Sudhakara and Nair (1986) reported higher panicle weight with effective weed control. Jayasree (1987) observed that weed control treatments improved grain filling and plumpiness. Mishra *et al.* (1989) reported reduction in 1000 grain weight, number of panicles per m^2, panicle weight in unweeded plots. Azad *et al.* (1990) also reported higher 1000 grain weight in weed control treatments including hand weeding as compared to unweeded check.

2.4.3 Yield reduction due to weeds

Severe weed competition is one of the major factors responsible for low yield in rice. Zimdahl (1980) reviewed the impact of weed competition on rice yield and majority of the works under review reported a yield reduction in the range of 20-30 per cent. Annual rice crop losses due to weeds were estimated at 10 to 50 per cent of potential production (De Datta, 1980).

Weed growth in early stages reduced crop yield more severely than in later stages (KAU, 1982). Yield losses due to weeds vary considerably from season to season and from year to year with an average of about 60 per cent of weeded plots (Moody, 1990). Yield reductions caused by uncontrolled weed growth through out a crop season have been estimated to be from 44 to 96 per cent, depending on the rice culture (Ampong-Nyarko and De Datta, 1991).

Sankaran and De Datta (1985) after reviewing the reports of many Indian workers reported a yield reduction of 32 to 86 per cent in upland rice due to uncontrolled weed growth. Ramiah and Muthukrishnan (1992) observed 11-30 per cent yield reduction in unweeded plots. Yield reduction of about 68 per cent in upland direct seeded rice was reported by Vaishya *et al.* (1992).

From a study on weed control in semi-dry rice in Kerala, in which *Sacciolepis interrupta* predominated, a yield loss of 73-86 per cent due to uncontrolled weed growth was reported (AICRP-WC, 1992; Sreedevi and Thomas, 1993). Competition of five *Sacciolepis* per m^2 reduced the rice yield by 34 per cent and competition above 40 plants per m^2 reduced the yield of rice by more than 40 per cent (AICRP-WC, 1997).

Infestation of 15 plants per m^2 of *Echinochloa crusgalli* significantly decreased grain yield (30.4%) as compared to weed free plots (Paradkar *et al.*, 1998). Incidence of *Echinochloa* for four weeks reduced rice yield by 40 per cent in upland direct seeded rice (Mandhal, 1990). In reducing yield, weed weight is more important than number. Zimdahl (1980) reported that rather than number, the weight of *Echinochloa crusgalli* was the determining factor in reducing the yield.

2.4.4 Nutrient drain by weeds

Weeds provide keener competition for nutrients than for water (Zimdahl, 1980).

Weeds removed 24 kg N, 7.5 kg P_2O_5 and 30.5 kg K_2O per hectare in an unweeded check (Varghese and Nair, 1986). Weed dry weight and N uptake by weeds were positively correlated (Singh and Dash, 1988).

Moorthy and Mittra (1990) reported removal of 19.4-33.7 kg N ha^{-1}, 1.5-18 kg P ha^{-1} and 17.4-33.7 kg K ha^{-1} from soil by weeds. Weeds when allowed to compete with crop depleted 25.8, 3.65 and 21.83 kg N, P_2O_5 and K_2O per hectare, respectively during Kharif season in upland rice (Ramamoorthy, 1991).

Many weed species have a nutrient uptake similar to that of rice, but have higher nutrient use efficiency than rice. The same factors that give a plant a competitive advantage in the uptake of water is responsible for a competitive advantage in nutrient uptake also (Ampong-Nyarko and De Datta, 1991).

Uptake of nutrients by weeds inside the crop canopy were comparatively lower than that grew without rice (Varughese, 1996). He also reported that NPK uptake by varying densities of *I. miliacea* increased with increasing densities.

2.4.5 Nutrient uptake by rice and competition

Crop N, P and K uptake was lowest in unweeded plots and in plots weeded 21 to 40 DAT. (Varghese and Nair, 1986). Uptake of N, P and K by rice was proportional to weed control efficiency (Moorthy and Mittra, 1990).

The uptake of NPK by rice was reduced from 80 to 64 per cent with increasing densities of *Isachne miliaceae* from 5 to 80 plants per m^2 (Varughese, 1996). Rice uptake of N decreased as weed density increased and this was reflected in decreased yields (Biswas and Sattar, 1991).

2.5 Management of *Sacciolepis interrupta*

Long term management of weed populations without excessive reliance on only one method is the main purpose of integrated weed management. Current weed management practices could be classified into direct and indirect methods. Indirect methods include general crop management practices that in addition to improving crop productivity also reduce weed infestations. Of the indirect methods, land preparation and water management are more critical for weed control. Direct methods refer to those that are designed mainly to control weeds. These are the use of herbicides, mechanical weeding and manual weeding. The stale seed bed technique and chemical control is considered here.

2.5.1 Stale seed bed technique

Careful land preparation provides weed-free conditions at planting. The method of land preparation influence the incidence of weeds (Sankaran and De Datta, 1985). According to Hosmani (1991), weed intensity is low in late sown kharif crops than early sown kharif crops. Similarly during the years when frequent pre-monsoon showers are received the weed intensity is lower as it favours weed germination and subsequent destroyal by tillage operations before sowing the crops.

Reduction of weeds in semi-dry rice culture is possible by practising a stale seed bed (Ampong-Nyarko and De Datta, 1991; Thomas and Abraham, 1998). In Stale seed bed technique, seeds are not sown immediately after land preparation. After land preparation, weeds are allowed to emerge following rain or irrigation, then destroyed by shallow cultivation or application of a non-residual contact herbicide. Rice is then seeded into the weed free field.

Stale seed bed technique is the most practical and widely used means of weed control in Iraq (Almamum *et al.*, 1986). Stale seed bed was recommended in mechanically transplanted and drill seeded rice in Egypt to reduce weed pressure. Paraquat 0.6 kg ha^{-1} at three days before planting was used when weeds have reached three leaf stage. Shallow harrowing was recommended before drilling rice (Hassan and Rao, 1996). Reduction in weed growth by stale seed bed was reported from Philippines (IRRI, 1979) also.

The usefulness of stale seed bed method in preventing successive weed flushes before seeding was reported in dry seeded rice in India (Mukhopadhyay, 1987; Moorthy, 1992). Stale seed bed proved superior to conventional method of land preparation in minimising weed competition (16-59%) and increased the yield of rice (18-73%). Moorthy (1992) also reported that cultivated stale seed bed was superior to chemical stale seed bed involving spraying of paraquat @ 1.0 lha^{-1} on the existing weeds before sowing rice.

Yaduraju and Mani (1987) observed that stale seed bed preparation had no effect on broad leaved weeds in wheat. However, both cultural and chemical treatments were equally effective in wild oat growth six weeks after sowing.

Stale seed bed treatments with post emergent herbicides, 500 g glyphosate, 420 g paraquat or tillage at sowing controlled *Ipomoea lacunosa* by more than 70 per cent in soyabean (Bruff and Shaw, 1992).

Reducing tillage or using shallow tillage results in a rapid depletion of seed bank (Yenish *et al.*, 1992). Many weed seeds in the germination zone germinate and emerge before planting. Foliar herbicides applied to control existing vegetation at planting will eliminate these weeds, and without additional tillage to bring up new seed, fewer weeds will be present later in the season (Shaw, 1996).

MATERIALS AND METHODS

He also found that stale seed bed approach was economically viable and agronomically feasible.

2.5.2 Chemical weed control

Application of pre-emergence herbicide is of special significance in dry seeded rice as it eliminates the competition at the initial stage itself. Trials at IRRI gave good weed control with pendimethalin 0.75, pretilachlor 0.5, oxyfluorfen 0.25, thiobencarb 1.0 and butachlor 0.75 kg ha^{-1} (IRRI, 1979).

In upland rice, oxyfluorfen effectively controlled all types of weeds from the germination stage, gave the lowest dry weight of weeds, highest number of panicles per m^2 and highest paddy yields (Ghosh and Singh, 1985). In transplanted rice, Azad *et al.* (1990) found that oxyfluorfen granules @ 0.2 kg ai ha^{-1} gave similar results when applied at 5 or 6 DAT. In Semi-dry rice also, oxyfluorfen was reported to be effective against weeds (Porpavai and Ramiah, 1992).

Regarding the phytotoxicity of oxyfluorfen application on rice, initial yellowing was noticed which was later recovered after about 2 to 3 weeks (Mukhopadhyay and Mandal, 1982). However, no inhibitory effect on rice seed germination was noted by the application of oxyfluorfen (Emmanuel *et al.*, 1991).

The application of oxyfluorfen in dry seeded rice recorded the maximum grain yield and effective weed control (KAU, 1986). Sreedevi and Thomas (1993) reported 100 per cent control of *Sacciolepis interrupta* in dry seeded rice using oxyfluorfen at 0.2 kg ha^{-1}. However, in terms of yield, the performance of oxyfluorfen @ 0.1 kg ha^{-1} was comparable and phytotoxicity problems was much less. The accepted recommendation for semi-dry rice in Kerala is oxyfluorfen 0.15 kg ha^{-1} on the day of sowing or 0.2 kg ha^{-1} within three days of sowing (KAU, 1996).

3. MATERIALS AND METHODS

A field experiment was conducted during the first crop season (*Virippu* - early *Kharif*) of 1999 to study the emergence pattern of *Sacciolepis interrupta* (Willd.) Stapf. and to test the feasibility of stale seed bed technique for the management of the weed.

3.1 General details

Experiment site

The experiment was conducted at the Agricultural Research Station, Mannuthy, Thrissur, Kerala. Geographically, the area is situated at 10°32' N latitude and 76°10' E longitude and at an altitude of 22.5 m above the mean sea level.

Climate and weather conditions

The experiment was conducted during the first crop season of 1999 (*Virippu* - early *Kharif*). The area experienced typical humid tropical climate. The weekly weather data for the cropping period obtained from the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara are presented in Appendix I and Fig.2.

Fig.2. Mean weather parameters during the crop growth period (Kharif 1999)

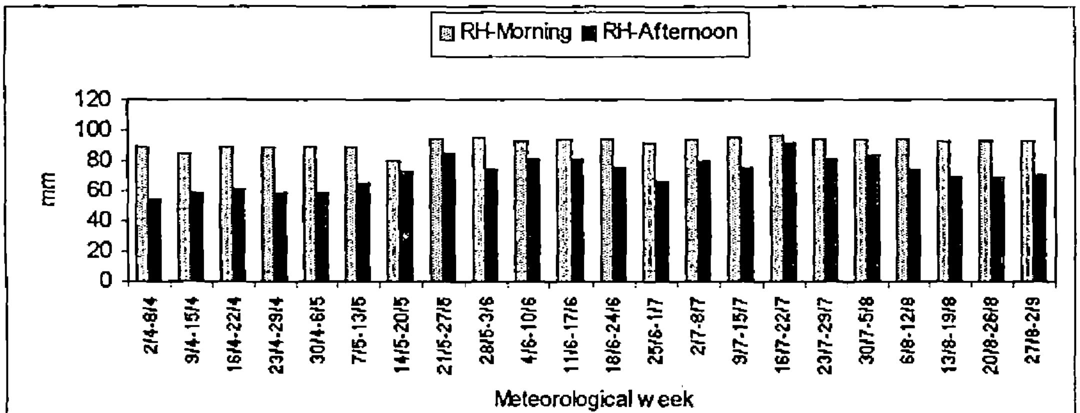

Fig. 2a. Morning and Afternoon relative humidity

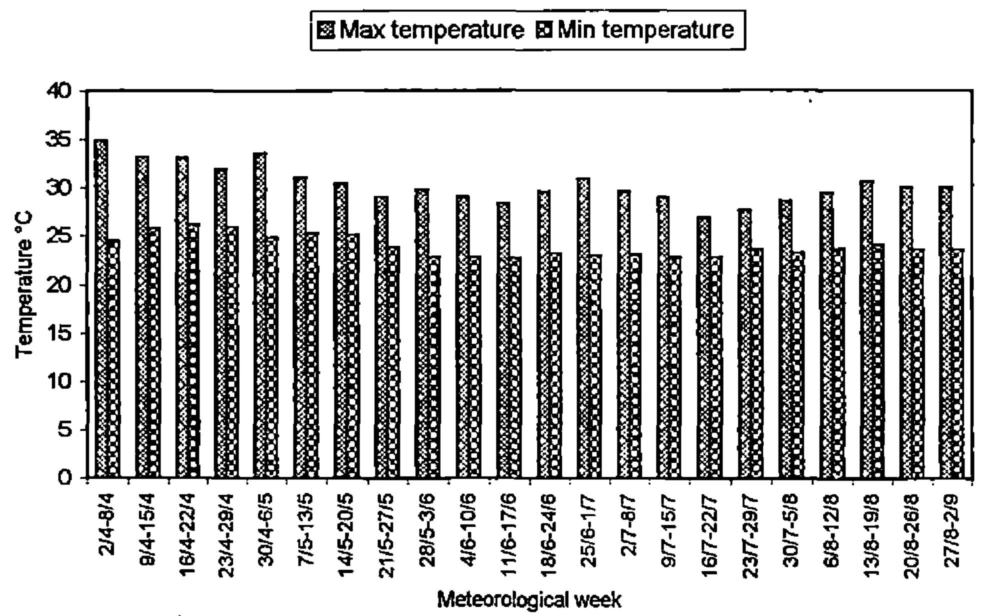

Fig. 2b. Maximum and Minimum temperature

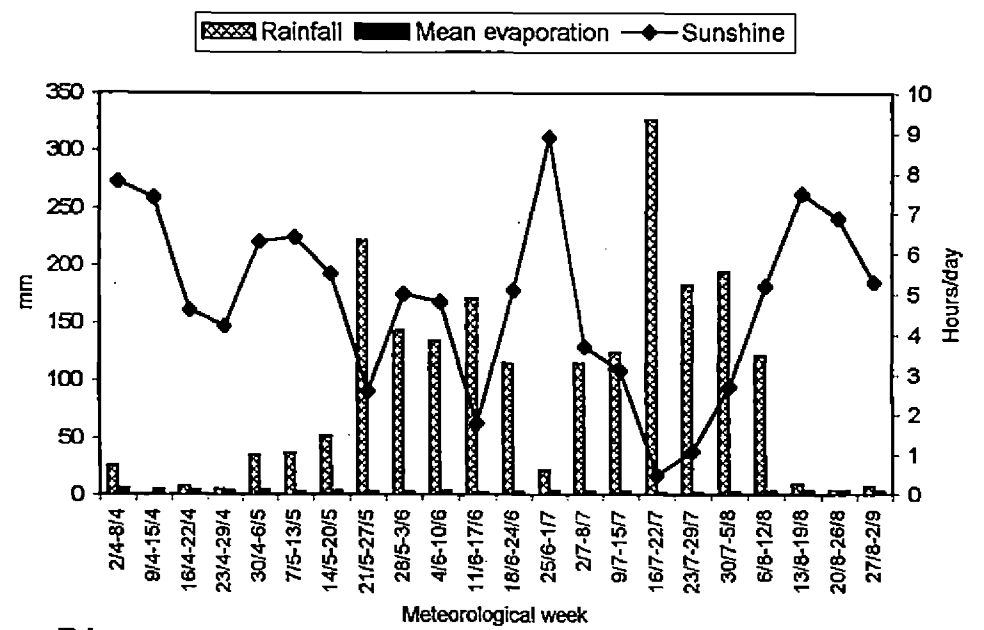

Fig. 2c. Rainfall, Evaporation and Hours of bright sunshine

Soil characteristics

The soil of the experimental area belongs to the broad soil type laterite (Order: Ultisols). These soils are low to medium in fertility. The soil was sandy clay loam in texture and acidic in reaction with a pH of 5.6. The physico-chemical properties of the soil are given in Table 1.

Table 1. Physico-chemical properties of the soil

Particulars	Value	Method used
A. Particle size analysis		
Coarse sand	27.2%	Hydrometer method (Piper, 1966)
Fine sand	23.8%	
Silt	22.6%	
Clay	26.4%	
Bulk density	1.52 g cm^{-3}	
B. Chemical composition		
Organic C	0.579%	Walkley and Black's rapid titration method (Jackson, 1958)
Total N	0.084%	Modified Kjeldal method (Jackson, 1958)
Available N	279.30 kg ha^{-1}	Alkaline permanganate distillation (Jackson, 1958)
Available P	79.79 kg ha^{-1}	Bray-I extractant-Ascorbic acid reductant method (Jackson, 1958)
Available K	112.00 kg ha^{-1}	Flame photometer (Jackson, 1958)
pH (1:2.5 soil water ratio)	5.6	Beckman glass electrode (Jackson, 1958)

Cropping history

The experimental site is a double crop paddy wet land, where a semi dry crop is taken during April-May to August-September and a transplanted crop during September-October to December-January every year. The land is usually left fallow during the summer season.

Rice cultivar used

Rice cultivar Jyothi was used for the study. Jyothi is a short duration cultivar (110-125 days) suited for semi-dry cultivation in double crop wet land. Jyothi is moderately tolerant to Brown Plant Hopper and Blast.

3.2 Experimental details

The whole investigation was grouped into three experiments. The details of the experiments are outlined below.

Experiment I. Field emergence of *Sacciolepis interrupta* (willd.) Stapf.

Three strips of size 5.0 x 1.5 m size were left unsown. On each strip, three microplots of size 0.25 m^2 (0.5 m x 0.5 m) each were marked and the emergence of *Sacciolepis* at weekly intervals was noted from the first receipt of rain. Rings of different colours were given for different flushes of weeds. At the end of the cropping season, surviving and dead plants were counted and recorded.

Experiment II. Germination studies

Seeds of *Sacciolepis* were collected during the previous year (*Kharif*, 1998) and stored. Germination tests were conducted at monthly intervals for one year and percentage germination was worked out.

Experiment III. Competition of *Sacciolepis interrupta* (Willd.) Stapf. modified by stale seed bed technique

The experiment was laid out in split plot in RBD with three main plots, four subplots and five replications. The layout of the experiment is given in Fig.3. The details are presented below:

Fig.3. Layout of the experiment "Competitiveness of *Sacciolepis interrupta* (Willd.) Stapf. modified by stale seed bed technique".

N

W — E

S

	S_1	W_3	W_2	W_1	W_4
R_1	S_3	W_1	W_3	W_4	W_2
	S_2	W_4	W_1	W_2	W_3
	S_3	W_1	W_2	W_4	W_3
R_2	S_2	W_1	W_3	W_2	W_4
	S_1	W_4	W_2	W_3	W_1
	S_2	W_2	W_1	W_4	W_3
R_3	S_3	W_1	W_3	W_2	W_4
	S_1	W_3	W_1	W_4	W_2
	S_1	W_2	W_4	W_3	W_1
R_4	S_3	W_3	W_1	W_2	W_4
	S_2	W_4	W_2	W_1	W_3
	S_1	W_4	W_1	W_2	W_3
R_5	S_2	W_2	W_4	W_1	W_3
	S_3	W_2	W_1	W_3	W_4

Main plot treatmets

S_1 - Normal Sowing

S_2 - Stale seed bed with hoeing

S_3 - Stale seed bed with paraquent spray @ .4kg ha^{-1}

Sub plot treatments

W_1 - Sacciolepis alone

W_2 - All weeds

W_3 - Oxyfluorfen @ 0.15 kg ha^{-1}

W_4 -Weed free

Treatments:

Main plot treatments

S_1 Normal sowing

S_2 Stale seed bed for 14 days with shallow hoeing

S_3 Stale seed bed for 14 days with paraquat spray @ 0.4 kg ha^{-1}

Sub plot treatments

W_1 *Sacciolepis* alone allowed to compete

W_2 All weeds allowed to compete

W_3 Pre-emergence spray of oxyfluorfen @ 0.15 kg ai ha^{-1}

W_4 Weed free

Gross plot size = 6 m x 2.5 m

Net plot size = 5 m x 2 m

The crop was dry dibbled @ 80 kg ha^{-1} at a spacing of 15 x 10 cm. An area of 1 m length at the end of each plot was earmarked for destructive sampling.

3.3 Field operations

The details of various field operations from land preparation to threshing in brief with their dates are given in Appendix II.

Land preparation

The experimental area was well ploughed and levelled. Plots of 6 m x 2.5 m size were prepared by constructing bunds of 30 cm width and 30 cm height. Irrigation channels were provided at suitable interval. According to the treatments proposed, stale seed beds were prepared by a shallow hoeing or application of paraquat @ 0.4 kg ha^{-1} after 14 days from final land preparation.

Sowing

The seeds of rice cultivar Jyothi were dry dibbled on 22nd April, 1999 on normal seed beds. After 14 days, seeds were sown on stale seed beds by dibbling. The spacing followed was 15 cm x 10 cm.

Fertilizer application

Urea (46% N), Mussorie Rockphosphate (18% P_2O_5) and Muriate of potash (60% K_2O) were used for supplying the nutrients. Fertilizers were applied as per the package of practices recommendation of Kerala Agricultural University (KAU, 1996) @ 70:35:35 kg N, P_2O_5 and K_2O respectively. Half of the nitrogen and full dose of phosphorus and potassium were applied as basal dose at the time of sowing. The remaining dose of nitrogen was applied at the maximum tillering stage.

Irrigation

Irrigation was provided for a week during the maximum tillering stage of the crop as there was delay in the receipt of rainfall.

Weeding

The weed management was done as per the treatments. The pre-emergence herbicide oxyfluorfen was applied on the third day after sowing @ 0.15 kg ha^{-1}. In plots where *Sacciolepis* were allowed to compete, all other weeds were removed by hand at suitable intervals. In weed free plots, all the weeds were removed at suitable intervals till flowering.

Plant protection

Stem borer attack was observed during the seedling stage of the crop and phosphamidon (Dimecron) @ 0.05 per cent was sprayed against it. Rice bug attack was noticed during the flowering stage. Methyl parathion (Metacid) @ 0.05 per cent was used for the control of rice bug.

Harvesting

The crop was harvested from the net plots after the grains matured. Threshing was done mannually and the produce was cleaned, dried and weighed and yield expressed as kg ha^{-1}.

3.4 Observations recorded

3.4.1 Experiment I. Field emergence of *Sacciolepis interrupta* (Willd.) Stapf.

Three strips were laid unsown and in each strip, three microplots of size 0.25 m^2 were marked. The different flushes of *Sacciolepis* were counted and were marked with different coloured rings. At the end of the season, number of plants survived and dead were counted and recorded.

3.4.2 Experiment II. Germination studies

Seeds of *Sacciolepis interrupta* were collected during the Kharif season of 1998. Germination tests were conducted at monthly intervals from the month of August onwards for one year. Germination percentage was worked out every month.

3.4.3 Experiment III. Competition of *Sacciolepis interrupta* (Willd.) Stapf. modified by stale seed bed

OBSERVATIONS ON RICE

Sampling procedure

Destructive plant samples were collected at random from the sampling area marked for destructive sampling using a quadrat of 0.5 m x 0.5 m size. The plants were uprooted and washed free of soil for recording observations on growth characters and yield components.

Tiller production

The number of vegetative tillers in one square metre area of each of the experimental plot on 15 DAS, 45 DAS and at harvest were counted and recorded.

Plant height

Height of ten plants was measured from ground level to the tip of the longest leaf on 15 DAS and 45 DAS. At harvest, it was measured from ground level to the tip of the longest panicle and expressed in centimetres.

Thousand grain weight

One thousand grains were counted from the bulk of each plot and their weight was recorded in grams.

Days to 50 per cent flowering

Number of days from seeding up to flowering of 50 per cent of the population was noted.

Grain and straw yield

The crop was harvested from each net plot area, threshed, winnowed and weight of straw and grain was recorded separately and expressed as kg ha^{-1}.

OBSERVATIONS ON WEEDS

Total weed count

The total number of weeds per square metre area were counted in each plot at various intervals. They were further separated as grasses, sedges and broad leaved weeds. The number of *Sacciolepis* were separately noted.

Total dry matter production of weeds

The weeds collected from 0.25 m^2 area was air dried and then oven dried at 80±5°C and dry weight was recorded as kg ha^{-1}.

Observations on *Sacciolepis*

Observations on the characters of *Sacciolepis* were made from the plots where *Sacciolepis* alone were maintained.

Height of *Sacciolepis*

The height of *Sacciolepis* was recorded by measuring the height up to the longest leaf from ground level for ten plants per plot and mean height was expressed in centimetres.

Days to 50 per cent flowering

The number of days from seeding of crop to flowering of 50 per cent of the population of *Sacciolepis* was counted.

Number of inflorescence per plant

The number of inflorescence in five selected samples of *Sacciolepis* was counted and mean number per plant was worked out.

Seeds per inflorescence

The seeds from the five randomly selected inflorescence of *Sacciolepis* were separated and counted.

Dry matter of *Sacciolepis* per unit area

Weight of *Sacciolepis* was obtained after oven drying the samples collected from 0.25 m^2 area and was expressed in kg ha^{-1}. Mean dry matter per plant was also worked out.

Leaf area per plant of *Sacciolepis*

The leaf area of ten *Sacciolepis* was obtained using leaf area meter and mean leaf area per plant was worked out.

3.5 Economics of weed control

The labour charges of the locality, cost of inputs and extra treatment costs were taken together and gross expenditure was computed and expressed in rupees per hectare. The price of paddy and that of the straw at current local market prices were taken as total receipts for computing gross return and expressed in rupees per hectare. Cost benefit ratio was worked out by dividing the gross return with the total expenditure per hectare.

3.6 Chemical analysis

Preparation of sample

Samples collected for the chemical analyses were oven dried at 80±5°C and ground in a Wiley mill. Before the actual weighing for analysis, it was once again oven dried.

Estimation of nutrient content

The N, P and K content of rice plants and *Sacciolepis* were separately analysed at harvest as explained by Jackson (1958). The total uptake of N, P and K were calculated as the product of the content of these nutrients and the plant dry weight and expressed in kg ha^{-1}.

Nitrogen content

Total nitrogen content in plant samples was determined by the Micro Kjeldahl distillation method (Jackson, 1958).

Phosphorus content

Plant sample was digested in a diacid mixture and the P content was determined by Vanadomolybdophosphoric yellow colour method (Jackson, 1958). Intensity of colour was read using Spectronic 20 spectrophotometer at 420 nm.

Potassium content

Potassium content in the diacid digest was estimated using EEL flamephotometer (Jackson, 1958).

3.7 Data analysis

Analyses of variance were performed on the data collected in Experiment III, using the statistical package `MSTAT' (Freed, 1986). Data on weed count and weed biomass that showed wide variation were subjected to square root transformation ($\sqrt{x+0.5}$) and logarithmic transformation [log(x+1)] respectively to make the analysis of variance valid (Gomez and Gomez, 1984). Multiple comparisons among treatment means where the F-test was significant (at 5 per cent level of significance) were done using the least significant difference (LSD).

RESULTS

4. RESULTS

Field and laboratory experiments on "Emergence and Competition of *Sacciolepis interrupta* (Willd.) Stapf." were conducted during the first crop season (*Virippu* - early *Kharif*) of 1999 at the Agricultural Research Station, Mannuthy. The data generated from the experiments conducted are presented and described here in appropriate Tables after having them statistically analysed.

4.1 Emergence of *Sacciolepis interrupta*

Different flushes of weeds emerged were counted at weekly intervals and presented in the Table 2a and 2b. Pre-monsoon showers were received during the week 2-4-99 to 8-4-99. First ploughing was given on 12-4-99. During the first week after the ploughing, 51.4 per cent of the *Sacciolepis* emerged. Subsequently, 35.7 per cent emerged during the second week, 7.1 per cent during the third week and 5.7 per cent during the fourth week. There was no further emergence of the weed after four weeks.

Table 2a. Emergence pattern of *Sacciolepis interrupta* (Willd.) Stapf.

Period after the receipt of rainfall	Emergence		Survived plants		Dead seedlings	
	Count No./m^2	Per cent	Count No./m^2	Per cent	Count No./m^2	Per cent
One week (22-4-99 to 29-4-99)	*4.7 (24)	51.4	4.2 (18.7)	77.7	2.1 (5.3)	22.2
Two week (30-4-99 to 6-5-99)	3.8 (16.7)	35.7	3.1 (10.7)	64.0	2.2 (6.0)	36.0
Three week (7-5-99 to 14-5-99)	1.7 (3.3)	7.1	1.4 (2.3)	60.0	1.2 (1.3)	40.0
Four week (15-5-99 to 22-5-99)	1.5 (2.7)	5.7	1.2 (1.3)	50.0	1.2 (1.3)	50.0
Five week (23-5-99 to 30-5-99)	0.7 (0.0)	0.0	0.7 (0.0)	0.0	0.7 (0.0)	0.0
SEm	0.4		0.3		0.3	
LSD (0.05)	1.2		1.0		0.8	

*$\sqrt{x} + 0.5$ transformed values. The figures in parenthesis are the original values

The results further revealed that 77.7 per cent of the plants emerged during the first week survived at maturity and 64 per cent of second week's emergence and 60 per cent of third week's emergence and 50 per cent of subsequent emergence survived at maturity.

Table. 2b. Effect of tillage on the emergence of *Sacciolepis interrupta*

Date of observation	No. of seedlings emerged per m^2	
	Ploughed on 12 - 4- 99	Ploughed on 8-5-99
29-4-99	24.0	0.0
5-5-99	16.7	0.0
12-5-99	3.3	50.0
19-5-99	2.7	42.6
26-5-99	0.0	22.0
2-6-99	0.0	(ploughed again)
9-6-99	0.0	24.3

The observations given in the Table 2b showed that when the land was not ploughed, there was no emergence even after the receipt of rains. Seed germination, however, continued when the soil was ploughed again. By 9th June, 1999, the field was flooded and no further emergence was noted.

Table 3. Seed germination of *Sacciolepis interrupta* (Willd.) Stapf. during different periods of the year

Month	Germination (%)
August	0
September	0
October	0
November	0
December	0
January	0
February	0
March	1.2
April	1.6
May	1.6
June	3.6
July	3.2

* Seeds collected in July 1998 were tested for germination at monthly intervals.

4.2 Germination studies

Germination percentage was worked out and are presented in Table 3. Germination studies were done from August, 1998 onwards at monthly interval. No germination occurred till the month of March. From March, germination was initiated but germination percentage was very low. Maximum germination percentage was obtained during June (3.6%) followed by July (3.2%).

4.3 Competition of *Sacciolepis interrupta* modified by stale seed bed

4.3.1 Effects on Rice

Leaf Area Index

Data on the leaf area index (LAI) of rice recorded at 15 and 45 DAS are presented in Table 4. The effect of stale seed bed on LAI was significant at both stages. Stale seed bed with paraquat spray @ 0.4 kg ha^{-1} recorded the maximum LAI which was on par with stale seed bed with hoeing. Normal sown crop recorded the least LAI.

Among the subplots, weed free plot recorded maximum LAI. *Sacciolepis* infested and unweeded plots were on par. The plot treated with oxyfluorfen @ 0.15 kg ai ha^{-1} recorded significantly lesser LAI than the unweeded plot and other plots at 15 DAS.

The effect of competition of weeds was found significant at 45 DAS also. The weed free plot recorded the maximum leaf area followed by oxyfluorfen applied plot. Unweeded plot recorded the least LAI. The plot infested with *Sacciolepis* showed higher LAI than unweeded plot.

The interaction effect was found to be significant at 15 DAS but not at 45 DAS. *Sacciolepis* competed, unweeded and weed free plots with both stale seed bed treatments had significantly higher LAI than the oxyfluorfen applied plots with stale seed bed. All the subplots with normal sowing treatment was on par in LAI

Table 4. Effect of treatments on leaf area index of rice at different stages

Main plot treatments	15 DAS				Main plot mean	45 DAS				Main plot mean
	Subplot treatments					Subplot treatments				
	Sacciolepis alone	All weeds	Oxyfluorfen	Weed free		*Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	
Normal sowing	0.18	0.17	0.10	0.18	0.16	1.38	1.23	1.68	2.89	1.80
Stale seed bed (hoeing)	0.86	0.85	0.43	0.99	0.78	3.65	2.69	4.30	4.52	3.79
Stale seed bed (paraquat)	0.90	0.86	0.47	0.96	0.80	3.66	3.10	4.55	4.72	4.01
Subplot mean	0.64	0.63	0.33	0.71		2.90	2.34	3.51	4.04	

15 DAS				45 DAS			
SEm main plot	- 0.04	LSD (0.05)	- 0.12	SEm main plot	- 0.21	LSD (0.05)	- 0.68
SEm subplot	- 0.03	LSD (0.05)	- 0.07	SEm subplot	- 0.16	LSD (0.05)	- 0.46
SEm subplot within main plot	- 0.04	LSD (0.05)	- 0.12	SEm subplot within main plot	- 0.28	LSD (0.05)	- NS

and had significantly lesser LAI as compared to all the subplots within the stale seed bed major plots.

Height of rice plants

The effect of sowing method and competition of weeds on the height of rice plants at various stages is presented in Table 5.

The height of rice was the lowest in normal sowing at 15 DAS and 45 DAS. Stale seed bed with paraquat application recorded the maximum height and was on par with stale seed bed with hoeing. There was no significant effect on height at harvest.

Among the subplots, at 15 DAS, oxyfluorfen treated plot recorded significantly lower plant height, than *Sacciolepis* infested, unweeded and weed free plots which were on par. At 45 DAS, maximum plant height was observed in weed free plot. *Sacciolepis* infested, oxyfluorfen applied and unweeded plots were on par at 45 DAS. At harvest, weed free plot recorded maximum height which was on par with *Sacciolepis* infested and oxyfluorfen treated plots. Unweeded plot recorded the least plant height.

The interaction effect was significant only at 15 DAS. All the subplot treatments except application of oxyfluorfen were on par and were significantly different. Oxyfluorfen application in stale seed bed with paraquat application reduced the height considerably compared to other subplot treatments which was on par with oxyfluorfen in stale seed bed with hoeing. All the plots with normal sowing recorded significantly lower plant height.

Dry matter production

The data on dry matter produced by rice at 15 DAS, 45 DAS and at harvest are furnished in Table 6.

Table 5. Effect of treatments on the height of rice plants at various growth stages (cm)

Main plot treatments	15 DAS				Main plot mean	45 DAS				Main plot mean	Harvest				Main plot mean
	Subplot treatments					Subplot treatments					Subplot treatments				
	Sacciolepis alone	All weeds	Oxyfluorfen	Weed free		*Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free		*Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	
Normal sowing	15.90	15.22	15.20	17.38	15.93	38.60	40.80	42.20	46.20	41.95	81.26	67.18	79.90	83.82	78.04
Stale seed bed (hoeing)	24.46	24.98	18.26	22.20	22.48	45.26	43.52	43.30	51.48	45.89	76.42	64.54	71.64	78.58	72.80
Stale seed bed (paraquat)	24.40	23.12	21.52	23.58	23.15	46.26	43.12	46.96	50.66	46.75	76.60	72.86	78.02	79.82	76.83
Subplot Mean	21.59	21.11	18.33	21.05		43.37	42.48	44.15	49.45		78.09	68.19	76.52	80.74	

15 DAS				45 DAS				Harvest			
SEm main plot	- 0.57	LSD (0.05)	- 1.87	SEm main plot	- 1.17	LSD (0.05)	- 3.82	SEm main plot	- 1.82	LSD (0.05)	- NS
SEm subplot	- 0.58	LSD (0.05)	- 1.68	SEm subplot	- 1.00	LSD (0.05)	- 2.88	SEm subplot	- 1.50	LSD (0.05)	- 4.31
SEm subplot within main plot	- 1.01	LSD (0.05)	- 2.91	SEm subplot within main plot	- 1.74	LSD (0.05)	- NS	SEm subplot within main plot	- 2.60	LSD (0.05)	- NS

Table 6. Dry matter production of rice as influenced by different treatments (kg ha^{-1})

Main plot treatments	15 DAS				Main plot mean	45 DAS					Harvest				Main plot mean
	Subplot treatments					Subplot treatments					Subplot treatments				
	Saccio-lepis alone	All weeds	Oxyflu-orfen	Weed free		*Saccio-lepis* alone	All weeds	Oxyflu-orfen	Weed free	Main plot mean	*Saccio-lepis* alone	All weeds	Oxyflu-orfen	Weed free	
Normal sowing	76.6	79.4	69.6	83.4	77.3	1142.2	1088.3	1146.2	2089.8	1366.6	3637.3	2003.4	3467.1	6965.1	4018.2
Stale seed bed (hoeing)	171.4	170.6	134.0	170.6	161.7	2669.8	1761.0	2122.2	2904.0	2361.8	4835.5	2927.7	6333.0	9018.6	5778.7
Stale seed bed (paraquat)	222.0	144.0	90.4	193.8	162.6	2713.8	1990.6	2539.2	2743.6	2496.8	4867.9	3815.5	5719.5	8968.3	5842.8
Subplot Mean	156.7	131.3	98.0	149.3		2171.9	1613.3	1935.9	2579.1		4486.9	2915.5	5173.2	8317.3	

15 DAS				45 DAS				Harvest			
SEm main plot	- 21.6	LSD (0.05)	- 70.5	SEm main plot	- 153.4	LSD (0.05)	- 500.2	SEm main plot	- 234.5	LSD (0.05)	- 764.8
SEm subplot	- 7.1	LSD (0.05)	- 20.4	SEm subplot	- 122.0	LSD (0.05)	- 350.0	SEm subplot	- 227.5	LSD (0.05)	- 680.9
SEm subplot within main plot	- 12.3	LSD (0.05)	- 35.4	SEm subplot within main plot	- 211.3	LSD (0.05)	- NS	SEm subplot within main plot	- 349.1	LSD (0.05)	- NS

Compared to normal sowing, stale seed bed plots recorded significantly higher dry matter production at all the stages.

At 15 DAS, the minimum dry matter production was noticed in oxyfluorfen treated plot. All the other subplot treatments were on par and superior to this.

At 45 DAS, maximum dry matter was recorded in weed free plot followed by *Sacciolepis* infested plot and oxyfluorfen applied plot which were on par. Dry matter production in unweeded plot was significantly low as compared to *Sacciolepis* infested plot but was on par with oxyfluorfen treated plot.

At harvest, significantly higher dry matter production was observed in weed free plot (8317.3 kg ha^{-1}) followed by oxyfluorfen treated plot (5173.2 kg ha^{-1}). The least biomass production was noticed in unweeded plot (2915.5 kg ha^{-1}). Compared to unweeded plot there was significantly higher dry matter production in *Sacciolepis* infested plot (4486.9 kg ha^{-1}).

The interaction effect was found to be significant at 15 DAS only. Biomass produced from *Sacciolepis* infested plot of stale seed bed with paraquat treatment was significantly higher and was on par with weed free plots in the same major plot. However, this weed free plot was on par with *Sacciolepis* infested and unweeded plots of stale seed bed with hoeing. All the subplot treatments under normal sowing and oxyfluorfen treated plot in chemical stale seed bed were inferior plots. Oxyfluorfen treated, normal sown plots recorded the least biomass. Oxyfluorfen treated stale seed bed with hoeing was superior to oxyfluorfen treated stale seed bed with paraquat.

Number of tillers

The mean number of tillers per m^2 at 15 DAS, 45 DAS and at harvest are presented in the Table 7.

Table 7. Effect of treatments on the tiller production of rice plants at different stages

Treatments	Tillers/m²		
	15 DAS	45 DAS	Harvest
Main plots (M)			
1. Normal sowing	209.8	325.4	452.3
2. Stale seed bed (hoeing	216.7	370.1	459.6
3. Stale seed bed (paraquat)	217.4	455.8	500.2
SEm	4.7	17.4	11.1
LSD (0.05)	NS	56.8	36.3
Subplots (S)			
1. *Sacciolepis* alone	229.7	386.3	467.8
2. All weeds	222.4	304.8	380.3
3. Oxyfluorfen @ 0.15 kg ha^{-1}	180.7	362.5	444.3
4. Weed free	225.7	481.4	590.3
SEm	12.3	14.7	15.7
LSD (0.05)	35.2	42.2	45.1
Interaction (M x S)			
SEm	21.3	25.5	27.2
LSD (0.05)	NS	NS	NS

The number of tillers were not affected due to the adoption of stale seed bed technique at 15 DAS. However, more number of tillers were recorded in stale seed bed with paraquat at 45 DAS and at harvest. The tiller production were on par in stale seed bed with hoeing and normal seed bed.

Among the competition levels, tiller production was significantly lesser in oxyfluorfen treated plot at 15 DAS. All the other subplot treatments were on par at 15 DAS. AT 45 DAS and at harvest, the maximum number of tillers were recorded in weed free plot followed by *Sacciolepis* infested plot which in turn were on par with oxyfluorfen treated plot. Unweeded plot recorded the least number of tillers at 45 DAS and harvest.

No significant interaction effect was noticed at all the three stages.

Days to 50 per cent flowering

The data on the number of days taken for flowering in 50 per cent of the plant population is furnished in Table 8. Rice plants in chemically treated and cultivated stale seed beds attained 50 per cent flowering in lesser number of days as compared to normal seed bed. Unweeded plots took significantly more number of days to flower than other competition levels, which were on par. There was no interaction effects.

Table 8. Effect of treatments on the days to 50 per cent flowering in rice.

Treatments	Days to 50% flowering
Main plots (M)	
1. Normal sowing	81.0
2. Stale seed bed (hoeing	74.6
3. Stale seed bed (paraquat)	74.3
SEm	0.6
LSD (0.05)	1.9
Subplots (S)	
1. *Sacciolepis* alone	76.2
2. All weeds	78.1
3. Oxyfluorfen @ 0.15 kg ha^{-1}	76.1
4. Weed free	75.9
SEm	0.1
LSD (0.05)	0.4
Interaction (M x S)	
SEm	0.2
LSD (0.05)	NS

Number of productive tillers

The number of panicles per square metre area were counted and the processed data is presented in Table 9. Stale seed bed technique significantly influenced the number of panicles. Paraquat applied stale seed bed recorded maximum panicles. In the weed free plots the number of panicles were significantly higher. When oxyfluorfen was applied @ 0.15 kg ha^{-1} or when *Sacciolepis* competed with the crop, the count of panicles per square metre was on par. Unweeded plot was severely affected and recorded the least number of panicles.

No significance was observed in interaction effect.

Number of grains per panicle

There was no significant effect due to the adoption of stale seed beds on the number of grains per panicle though numerically more grains per panicle were observed in stale seed beds than normal sowing.

Table 9. Effect of treatments on the yield attributes of rice

Treatments	No. of panicle m^{-2}	No. of grains per panicle	1000 grain weight (g)	Percentage of filled grains
Main plots (M)				
1. Normal sowing	306.2	49.3	26.6	70.1
2. Stale seed bed (hoeing)	352.1	55.9	28.4	80.2
3. Stale seed bed (paraquat)	386.1	56.3	28.2	79.6
SEm	19.4	3.2	0.6	0.6
LSD (0.05)	39.4	NS	NS	2.1
Sub plots (S)				
1. *Sacciolepis* alone	307.4	55.5	27.7	74.8
2. All weeds	269.1	39.4	27.2	69.8
3. Oxyfluorfen @ 0.15 kg ha^{-1}	348.5	52.9	27.8	77.2
4. Weed free	467.4	67.5	28.4	84.8
SEm	15.9	1.8	0.3	0.7
LSD (0.05)	45.5	5.1	NS	1.9
Interaction				
SEm	27.5	3.1	0.6	1.2
LSD (0.05)	NS	NS	NS	3.4

The number of grains per panicle was significantly influenced by the weed competition (Table 9). Weed free plot recorded more number of grains per panicle (68 no.) while the competition effect of *Sacciolepis* and the effect of oxyfluorfen were on par. Unweeded plot recorded the least number of grains per panicle (39 no.).

Interaction effect was absent.

Test weight of grains

Stale seed beds as well as weed competition showed no significant influence on the thousand grain weight of the crop. However, the stale seed bed plots recorded slightly higher grain weight. Weed free plots also recorded apparently higher test weight.

Percentage of filled grains

The crops grown on stale seed beds produced significantly higher number of filled grains as compared to normal sowing (Table 9). A higher percentage of filled grains was obtained from chemical stale seed bed, which was on par with cultivated stale seed bed.

Weed free plot yielded the highest percentage of filled grains (85%) while competition due to the presence of all weeds significantly reduced the filled grain percentage (70%). *Sacciolepis* infestation, though reduced the fertile grain percentage considerably, was superior to unweeded plot.

Interaction effect was also significant (Table 10). Highest percentage of filled grains was obtained in weed free plots of both the stale seed bed which were followed by oxyfluorfen treated plots of stale seed beds. *Sacciolepis* infested plot in stale seed bed with hoeing was on par with oxyfluorfen applied stale seed bed and weed free plot of normal sowing. Even the unweeded plot in stale seed bed with hoeing was on par with normally sown weed free plot. Lowest percentage of filled grains was recorded in unweeded plots of normally sown crop.

Table 10. Effect of treatments on the percentage of filled grains

Main plot treatments	Subplot treatments				
	Percentage filled grains				
	Sacciolepis alone	Control	Oxyfluorfen	Weed free	Main plot Mean
Normal sowing	69.6	60.8	71.7	78.3	70.1
Stale seed bed (hoeing)	78.3	75.5	80.1	87.1	80.2
Stale seed bed (paraquat)	76.4	73.1	79.8	89.0	79.6
Subplot mean	74.8	69.8	77.2	84.8	

SEm main plot	- 0.63	LSD (0.05)	- 2.057
SEm subplot	- 0.67	LSD (0.05)	- 1.925
SEm subplot within main plot	- 1.16	LSD (0.05)	- 3.335

Grain yield of rice

Rice grain yield was significantly influenced by the seed beds (Table 11). The stale seed beds were superior to normal seed beds. The maximum yield was obtained from stale seed bed with paraquat application (2566.6 kg ha^{-1}) which was on par with cultivated stale seed bed (2531.2 kg ha^{-1}). Normal seed bed recorded the lowest yield (1744.6 kg ha^{-1}).

Table 11. Effect of treatments on grain yield, straw yield, biological yield and harvest index of rice.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
Main plots				
Normal sowing	1744.6	2273.7	4018.2	0.43
Stale seed bed (hoeing)	2531.2	3247.5	5778.7	0.44
Stale seed bed (paraquat)	2566.6	3276.3	5842.8	0.44
SEM	130.5	213.6	234.5	0.14
LSD(0.05)	255.0	499.8	589.7	NS
Sub plots				
Sacciolepis alone	1888.2	2558.7	4486.9	0.43
All weeds	1216.2	1699.3	2915.5	0.42
Oxyfluorfen @ 0.15 kg ha^{-1}	2236.5	2936.7	5173.2	0.43
Weed free	3782.1	4535.2	8317.3	0.46
SEm	102.7	156.8	227.5	0.01
LSD (0.05)	294.4	389.5	680.9	0.02
Interaction				
SEm	177.8	271.6	349.1	0.01
LSD (0.05)	NS	NS	NS	NS

Uncontrolled weed growth reduced the grain yield considerably (1216.2 kg ha^{-1}). Yield reduction due to the competition of *Sacciolepis* (1888.2 kg ha^{-1}) was considerably higher compared to oxyfluorfen applied or weed free plots. Weed free plot gave the highest grain yield (3782.1 kg ha^{-1}). Oxyfluorfen application, however, recorded significantly lower yield (2236.5 kg ha^{-1}) than weed free plot.

Interaction was absent.

Straw yield

The normally sown crop produced the lower straw yield than the stale seed beds (Table 11). Both the stale seed beds were on par.

The effect of weed competition on straw yield was highly significant. Maximum straw yield (4535 kg ha^{-1}) was obtained from weed free plots whereas the minimum yield (1699.3 kg ha^{-1}) was from unweeded plot. Straw yield from *Sacciolepis* infested and oxyfluorfen applied plots were on par.

Biological yield

The data on the biological yield are presented in Table 11. Total biomass production of rice at harvest was considerably high in stale seed bed with paraquat (5842.8 kg ha^{-1}) which was on par with cultivated stale seed bed (5778.7 kg ha^{-1}). Weed free plot produced significantly high biomass (8317.3 kg ha^{-1}) which was immediately followed by oxyfluorfen applied plot (5173.2 kg ha^{-1}). *Sacciolepis* infested plot recorded high biomass production (4486.9 kg ha^{-1}) than unweeded plot (2915.5 kg ha^{-1}).

Harvest index

Harvest index was significant only between subplot treatments (Table 11). The highest harvest index was obtained from weed free plot (0.46) which was followed by oxyfluorfen treated plot and *Sacciolepis* infested plot. Unweeded plot recorded the lowest harvest index and was on par with *Sacciolepis* infested and unweeded plots.

Nutrient uptake by rice

Nitrogen

Nitrogen uptake in the normal crop was significantly lower as compared to that of stale seed beds (Table 12). Stale seed bed with paraquat favoured better uptake of nitrogen which was followed by stale seed bed with hoeing. The least N uptake was noticed in normal crop.

Table 12. Effect of treatments on nutrient uptake by crop at harvest (kg ha^{-1})

Treatments	Nitrogen uptake	Phosphorus uptake	Potassium uptake
Main plots (M)			
1. Normal sowing	37.4	11.0	21.5
2. Stale seed bed (hoeing)	49.2	13.4	33.1
3. Stale seed bed (paraquat)	52.1	12.5	31.1
SEm	2.8	0.6	1.8
LSD (0.05)	9.0	2.0	5.8
Sub plots (S)			
1. *Sacciolepis* alone	37.0	10.4	24.9
2. All weeds	25.7	6.6	16.2
3. Oxyfluorfen @ 0.15 kg ha^{-1}	46.1	12.1	28.5
4. Weed free	75.9	20.2	44.6
SEm	2.3	0.6	1.3
LSD(0.05)	8.6	1.8	3.7
Interaction (M x S)			
SEm	3.9	1.1	2.2
LSD (0.05)	NS	NS	NS

Weed competition showed significant effect on nitogen uptake by the crop. Weed free plot recorded the highest nitrogen uptake at harvest. Oxyfluorfen treated plot recorded high nitrogen uptake which was followed by *Sacciolepis* infested plot. Unweeded plots showed the least uptake of nitrogen.

The interaction effect was non-significant.

Phosphorus

Significant effect was noticed due to stale seed bed on phosphorus uptake of the crop (Table 12). Stale seed bed with paraquat showed significantly higher P uptake followed by stale seed bed with hoeing. Normal crop absorbed lesser amount of phosphorus. Among the subplots, weed free plot recorded significantly higher P uptake which was followed by oxyfluorfen treated plot. *Sacciolepis* infested plot recorded high P content as compared to unweeded plots. No significant interaction effect was noticed.

Potassium

Stale seed bed significantly influenced the potassium uptake by the crop at harvest (Table 12). Stale seed bed with hoeing recorded the maximum K uptake which was on par with the stale seed bed with paraquat. Normal sowing recorded the least uptake of K.

Significantly higher uptake of K was noticed in weed free plot. K uptake in oxyfluorfen applied plot and *Sacciolepis* infested plot was on par. Unweeded plot recorded the least K uptake.

Interaction was not significant.

4.3.2 Effects on weeds

Number of *Sacciolepis* per square meter

The mean number of *Sacciolepis* per m^2 at 15 DAS, 45 DAS and 90 DAS are furnished in Table 13.

Stale seed bed with paraquat showed significant effect in reducing the *Sacciolepis* count per m^2 at all the stages. Stale seed bed with hoeing was on par with stale seed bed with paraquat at 15 DAS. However, at 45 DAS and 90 DAS, cultivated stale seed bed was intermediate in performance. Normal sowing recorded the highest count of *Sacciolepis* at all the stages.

Table 13. Effect of treatments on the number of *Sacciolepis* per m^2

Main plot treatments	15 DAS				Main plot mean	45 DAS				Main plot mean	90 DAS				Main plot mean
	Subplot treatment					Subplot treatment					Subplot treatment				
	Sacciolepis alone	All weeds	Oxyfluorfen	Weed free		*Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free		*Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	
Normal sowing	5.93* (39.2)	4.86 (25.0)	0.71 (0.0)	0.71 (0.01)	3.05 (16.1)	5.59 (31.6)	4.30 (22.6)	2.00 (4.2)	0.71 (0.0)	3.00 (14.6)	5.39 (28.8)	4.56 (21.0)	1.79 (3.8)	0.71 (0.0)	3.11 (13.4)
Stale seed bed (hoeing)	3.61 (15.6)	1.55 (3.6)	0.71 (0.0)	0.71 (0.0)	1.65 (4.8)	3.7 (14.0)	2.7 (9.8)	1.64 (3.6)	0.71 (0.0)	2.20 (6.9)	3.81 (14.2)	3.39 (12.4)	1.99 (4.6)	0.71 (0.0)	2.47 (7.9)
Stale seed bed (paraquat)	1.91 (5.6)	1.88 (4.0)	0.71 (0.0)	0.71 (0.0)	1.05 (1.5)	2.62 (7.2)	1.89 (3.2)	1.32 (2.0)	0.71 (0.0)	1.64 (3.2)	3.097 (9.4)	2.95 (9.8)	1.09 (1.00)	0.71 (0.0)	1.96 (5.1)
Mean	3.82 (20.1)	2.43 (9.7)	0.71 (0.0)	0.71 (0.0)		3.98 (17.6)	2.97 (12.0)	1.9 (3.3)	0.71 (0.0)		4.09 (17.5)	3.63 (14.5)	1.63 (3.1)	0.71 (0.0)	

	15 DAS			45 DAS			90 DAS		
	SEm	LSD (0.05)		SEm	LSD (0.05)		SEm	LSD (0.05)	
SEm main plot	- 0.15	LSD (0.05)	- 0.48	- 0.21	LSD (0.05)	- 0.69	- 0.21	LSD (0.05)	- 0.69
SEm subplot	- 0.27	LSD (0.05)	- 0.77	- 0.24	LSD (0.05)	- 0.70	- 0.21	LSD (0.05)	-0.59
SEm subplot within main plot	- 0.47	LSD (0.05)	- 1.34	- 0.42	LSD (0.05)	- 1.21	- 0.36	LSD (0.05)	- 1.03

* $\sqrt{x+0.5}$ transformed values. The figures in parenthesis are the original values.

At 15 DAS and 45 DAS, oxyfluorfen treated plot was on par with weed free plot while oxyfluorfen treated plot showed significantly higher *Sacciolepis* count than weed free plot at 90 DAS. *Sacciolepis* count was maximum in *Sacciolepis* competed plot followed by unweeded plot at 15 DAS and 45 DAS and was on par with unweeded plot at 90 DAS.

Interaction was also significant at all the three stages. At 15 DAS, *Sacciolepis* infested plot in normal seed bed recorded the higher count followed by unweeded plot in normal seed bed and *Sacciolepis* infested plot in stale seed bed with hoeing, which were on par. All other interactions recorded lesser number of *Sacciolepis* which were all on par.

At 45 DAS, oxyfluorfen treated plots in all the three seed bed treatments were on par with weed free plots. However, at 90 DAS, oxyfluorfen treated plot in normal seed bed recorded significantly higher number of *Sacciolepis* which was on par with oxyfluorfen treated plots in stale seed bed. The effect of application of oxyfluorfen in stale seed bed with paraquat was on par with weed free plots.

Total number of weeds

The count of total weeds at 15 DAS, 45 DAS and 90 DAS are presented in Table 14.

At 15 DAS, there was no significant effect of stale seed bed on weed count. Unweeded plot recorded maximum weed count at all the stages. Weed density in *Sacciolepis* competed plot was on par with oxyfluorfen treated plot. Weed free plot was the superior plot which was on par with oxufluorfen treated plot.

Weed count in unweeded plot was on par with plots treated with oxyfluorfen at 45 DAS and 90 DAS. *Sacciolepis* infested plot recorded significantly higher weed density as compared to weed free plot.

At 45 DAS and 90 DAS, normal seed bed favoured significantly higher weed density than stale seed beds. Stale seed bed with hoeing had lower weed density as compared to normal sowing. Weed count was significantly less in chemically treated stale seed bed than the other two seed beds.

Interaction had no significant effect on weed density.

Table 14. Effect of treatments on total number of weeds per m^2 at various stages

Treatments	15 DAS	45 DAS	90 DAS
Main plots (M)			
1. Normal sowing	4.04* (28.65)	6.34 (58.55)	6.39 (55.25)
2. Stale seed bed (hoeing)	3.45 (21.90)	4.69 (36.80)	5.56 (43.75)
3. Stale seed bed (paraquat)	2.85 (16.50)	3.91 (23.95)	4.77 (33.60)
SEm±	0.37	0.43	0.22
LSD (0.05)	NS	1.40	0.711
Sub plot (S)			
1. *Sacciolepis* alone	3.78 (20.13)	3.76 (17.60)	4.03 (17.47)
2. All weeds	7.61 (65.13)	7.99 (71.87)	9.05 (83.87)
3. Oxyfluorfen @ 0.15 kg ha^{-1}	1.69 (4.13)	7.46 (69.60)	8.50 (75.46)
4. Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
SEm±	0.51	0.59	0.29
LSD (0.05)	1.46	1.66	0.81
Interaction			
M x S	NS	NS	NS

* $\sqrt{x+0.5}$ transformed values. The figures in parenthesis are the original values.

Total weed biomass

Stale seed bed had no effect on weed biomass at 15 DAS but had significant effects at 45 and 90 DAS (Table 15). At 45 DAS and 90 DAS, plots with normal sowing recorded significantly higher weed biomass as compared to

Table 15. Biomass production of weeds at different stages as influenced by different treatments (kg ha^{-1})

Main plot treatments	15 DAS Subplot treatments: *Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	Main plot mean	45 DAS Subplot treatments: *Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	Main plot mean	90 DAS Subplot treatments: *Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	Main plot mean
Normal sowing	1.07* (4.6)	1.89 (79.0)	0.10 (0.28)	0.00 (0.0)	0.77 (25.4)	3.06 (1221.6)	3.06 (1210.1)	2.85 (771.0)	0.00 (0.0)	2.24 (800.7)	3.52 (3519.6)	3.47 (3100.0)	3.28 (2064.0)	0.00 (0.0)	2.57 (2171.2)
Stale seed bed (hoeing)	1.14 (47.2)	1.51 (72.8)	0.56 (10.0)	0.00 (0.0)	0.80 (32.5)	2.43 (328.6)	2.67 (575.8)	2.38 (274.0)	0.00 (0.0)	1.87 (294.6)	3.22 (1667.2)	3.28 (1905.4)	2.77 (647.6)	0.00 (0.0)	2.32 (1055.1)
Stale seed bed (paraquat)	0.61 (13.2)	1.74 (73.8)	0.70 (6.58)	0.00 (0.0)	0.76 (23.5)	2.25 (215.2)	2.40 (401.6)	2.25 (252.2)	0.00 (0.0)	1.73 (217.3)	2.99 (1160.0)	3.05 (1210.6)	2.63 (496.8)	0.00 (0.0)	2.17 (716.6)
Subplot Mean	0.94 (27.5)	1.71 (75.2)	0.45 (5.8)	0.00 (0.0)		2.58 (588.5)	2.71 (729.2)	2.49 (432.4)	0.00 (0.0)		3.25 (2115.6)	3.27 (2072.2)	2.89 (1069.2)	0.00 (0.0)	

	15 DAS		45 DAS		90 DAS	
SEm main plot	- 0.08	LSD (0.05) - NS	- 0.06	LSD (0.05) - 0.19	- 0.03	LSD (0.05) - 0.10
SEm subplot	- 0.16	LSD (0.05) - 0.45	- 0.06	LSD (0.05) - 0.16	- 0.04	LSD (0.05) - 0.10
SEm subplot within main plot	- 0.27	LSD (0.05) - NS	- 0.10	LSD (0.05) - 0.28	- 0.07	LSD (0.05) - 0.20

* log (x+1) transformed values. The figures in parenthesis are the original values.

stale seed bed with paraquat. However, the latter was on par with stale seed bed with hoeing at 45 DAS. At 90 DAS, cultivated stale seed bed recorded higher biomass of weeds than stale seed bed with paraquat.

Unweeded plots recorded the maximum weed biomass at all the stages. Weed biomass in *Sacciolepis* alone plot was intermediate at 15 DAS. However, the weed biomass in *Sacciolepis* infested, unweeded and oxyfluorfen treated plots were on par at 45 DAS. At 90 DAS, both *Sacciolepis* infested and unweeded plots recorded high weed biomass. Oxyfluorfen treated plots showed lower weed biomass as compared to unweeded plots.

Interaction showed significance at 45 DAS and 90 DAS. *Sacciolepis* infested and unweeded plots in normal sowing recorded higher weed biomass compared to others.

Number of grass weeds other than *Sacciolepis*

The data on the grass weed count is recorded in Table 16. Oxyfluorfen applied plot recorded significantly lesser grass weeds than unweeded plot. Stale seed bed showed no significant influence on the count at 15 DAS and 45 DAS. Interaction was found to be significant at 15 DAS and 90 DAS.

At 15 DAS, unweeded plot in normal sowing treatment recorded significantly higher count of grass weeds followed by unweeded plot within stale seed bed with paraquat application. Unweeded plot within stale seed bed with hoeing and oxyfluorfen applied plots in both the stale seed beds were on par. Oxyfluorfen treated normal plot was on par with weed free plots.

Most dominant grass apart from *Sacciolepis interrupta* observed was *Echinochloa colona*. The effect of oxyfluorfen was significantly lesser as compared with unweeded plot at 15 DAS and 45 DAS and 90 DAS. At 15 DAS

Table 16. Effect of treatments on the count of grass weeds other than *Sacciolepis interrupta* per m^2 at different stages

Main plot treatments	15 DAS				Main plot mean	45 DAS				Main plot mean	90 DAS				Main plot mean
	Subplot treatments					Subplot treatments					Subplot treatments				
	Saccio-lepis alone	All weeds	Oxyflu-orfen	Weed free		*Saccio-lepis* alone	All weeds	Oxyflu-orfen	Weed free		*Saccio-lepis* alone	All weeds	Oxyflu-orfen	Weed free	
Normal Sowing	0.71* (0.0)	6.39 (45.0)	1.22 (1.2)	0.71 (0.0)	2.26 (11.6)	0.71 (0.0)	6.14 (38.4)	7.07 (61.6)	0.71 (0.0)	3.66 (25.0)	0.71 (0.0)	6.76 (48.4)	8.33 (72.8)	0.71 (0.0)	4.13 (30.3)
Stale seed bed (hoeing)	0.71 (0.0)	2.51 (11.2)	2.06 (6.8)	0.71 (0.0)	1.49 (4.5)	0.71 (0.0)	4.34 (22.2)	4.12 (20.8)	0.71 (0.0)	2.47 (10.8)	0.71 (0.0)	5.37 (29.8)	5.73 (34.2)	0.71 (0.0)	3.13 (16.6)
Stale seed bed (paraquat)	0.71 (0.0)	3.86 (21.2)	2.01 (4.4)	0.71 (0.0)	1.82 (6.4)	0.71 (0.0)	5.44 (32.8)	2.27 (8.8)	0.71 (0.0)	2.28 (10.4)	0.71 (0.0)	1.91 (7.8)	2.73 (11.2)	0.71 (0.0)	1.51 (4.8)
Subplot Mean	0.71 (0.0)	4.26 (25.8)	1.76 (4.1)	0.71 (0.0)		0.71 (0.0)	5.31 (31.1)	4.49 (30.4)	0.71 (0.0)		0.71 (0.0)	4.68 (28.7)	5.59 (39.4)	0.71 (0.0)	

	15 DAS			45 DAS			90 DAS		
	SEm main plot	- 0.33	LSD (0.05) - NS	SEm main plot	- 0.38	LSD (0.05) - NS	SEm main plot	- 0.37	LSD (0.05) - 1.20
	SEm subplot	- 0.35	LSD (0.05) - 1.00	SEm subplot	- 0.47	LSD (0.05) - 1.34	SEm subplot	- 0.34	LSD (0.05) -0.96
	SEm subplot within main plot	- 0.61	LSD (0.05) - 1.74	SEm subplot within main plot	- 0.81	LSD (0.05) - NS	SEm subplot within main plot	- 0.58	LSD (0.05) - 1.67

* $\sqrt{x+0.5}$ transformed values. The figures in parenthesis are the original values.

Table 17. Effect of treatments on the number of broad leaf weeds per m²

Main plot treatments	15 DAS Subplot treatments: *Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	Main plot mean	45 DAS Subplot treatments: *Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	Main plot mean	90 DAS Subplot treatments: *Sacciolepis* alone	All weeds	Oxyfluorfen	Weed free	Main plot mean
Normal sowing	0.71* (0.0)	1.77 (3.0)	0.71 (0.0)	0.71 (0.0)	0.97 (0.8)	0.71 (0.0)	1.38 (3.2)	4.03 (60.0)	0.71 (0.0)	1.71 (15.8)	0.71 (0.0)	3.37 (13.0)	2.45 (10.4)	0.71 (0.0)	1.81 (5.9)
Stale seed bed (hoeing)	0.71 (0.0)	5.47 (48.8)	0.71 (0.0)	0.71 (0.0)	1.90 (12.2)	0.71 (0.0)	5.17 (52.4)	2.03 (6.2)	0.71 (0.0)	2.15 (14.7)	0.71 (0.0)	6.24 (38.8)	4.01 (17.6)	0.71 (0.0)	2.92 (14.1)
Stale seed bed (paraquat)	0.71 (0.0)	3.47 (28.0)	0.71 (0.0)	0.71 (0.0)	1.40 (7.0)	0.71 (0.0)	2.59 (11.6)	3.73 (16.2)	0.71 (0.0)	1.94 (6.9)	0.71 (0.0)	6.44 (41.4)	6.55 (46.6)	0.71 (0.0)	3.60 (22.0)
Subplot Mean	0.71 (0.0)	3.57 (26.6)	0.71 (0.0)	0.71 (0.0)		0.71 (0.0)	3.05 (22.4)	3.26 (7.5)	0.71 (0.0)		0.71 (0.0)	5.35 (31.1)	4.34 (24.9)	0.71 (0.0)	

	15 DAS		45 DAS		90 DAS	
	SEm	LSD (0.05)	SEm	LSD (0.05)	SEm	LSD (0.05)
Main plot	0.40	NS	0.49	NS	0.19	0.61
Subplot	0.50	1.44	0.75	2.16	0.32	0.92
Subplot within main plot	0.87	NS	1.31	NS	0.55	1.59

* √x+0.5 transformed values. The figures in parenthesis are the original values.

Number of sedges

Method of sowing had no significant effect on the count of sedges at any of the stages of observation (Table 18). No sedges were recorded in oxyfluorfen applied plots at 15 DAS. However, by 45 DAS number of sedges in oxyfluorfen applied plots and unweeded plots were on par. *Cyperus iria* was the most dominant sedge.

Table 18. Effect of treatments on count of sedges per m^2 at different stages

Treatments	15 DAS	45 DAS	90 DAS
Main plots (M)			
1. Normal sowing	0.82* (0.3)	1.45 (4.2)	1.71 (5.7)
2. Stale seed bed (hoeing)	0.82 (0.4)	1.60 (4.55)	1.90 (5.8)
3. Stale seed bed (paraquat)	0.96 (1.6)	1.39 (3.4)	1.23 (1.8)
SEm±	0.17	0.34	0.28
LSD (0.05)	NS	NS	NS
Sub plot (S)			
1. *Sacciolepis* alone	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
2. All weeds	1.34 (3.07)	1.89 (6.33)	2.69 (9.69)
3. Oxyfluorfen @ 0.15 kg ha^{-1}	0.71 (0.0)	2.61 (9.87)	2.37 (8.07)
4. Weed free	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
SEm±	0.19	0.35	0.30
LSD (0.05)	NS	1.01	0.86
Interaction			
M x S	0.33	0.61	0.52
SEm±	NS	NS	NS

* $\sqrt{x+0.5}$ transformed values. The figures in parenthesis are the original values.

4.3.3 Effects of stale seed bed on important plant characters of *Sacciolepis interrupta* (Willd.) Stapf.

Biomass of *Sacciolepis*

The mean total biomass of *Sacciolepis* as affected by stale seed bed technique is given in Table 19a.

At 15 DAS biomass of *Sacciolepis* per hectare was significantly higher in Stale seed bed with hoeing while normal plot recorded least biomass. At 45 DAS and 90 DAS, Biomass of *Sacciolepis* was high in normal seed bed followed by stale seed bed with hoeing which was on par with chemical stale seed bed, which recorded the least biomass production of Sacciolepis. However, highest per plant biomass was obtained in stale seed bed with paraquat and least in normal seed bed (Table 19b).

Table 19a. Effect of stale seed bed technique on the biomass production of *Sacciolepis* (kg ha^{-1})

Treatments	15 DAS	45 DAS	90 DAS
Normal sowing	36.4	585.4	3119.6
Stale seed bed (hoeing)	74.1	282.6	1667.2
Stale seed bed (paraquat)	50.7	175.2	1160.0
SEm	8.9	43.1	458.6
LSD (0.05)	29.0	140.4	1496.0

Table 19b. Effect of stale seed bed technique on biomass production of *Sacciolepis* (g/plant)

Treatments	15 DAS	45 DAS	90 DAS
Normal sowing	0.14	1.65	13.52
Stale seed bed (hoeing)	0.57	1.89	13.78
Stale seed bed (paraquat)	0.59	1.93	11.64
SEm	0.07	0.35	1.15
LSD (0.05)	0.23	NS	NS

Leaf area index of *Sacciolepis*

Leaf area index of *Sacciolepis* are presented in Table 20a. LAI of Sacciolepis at 45 DAS and 90 DAS was significantly higher in normal plots whereas stale seed bed with paraquat application recorded least LAI. Though LAI of *Sacciolepis* in stale seed bed with hoeing was high at 45 DAS, it was on par with stale seed bed with paraquat at 90 DAS. No significant effect was noticed on leaf area per plant due to the effect of stale seed bed (Table 20b). Maximum leaf area observed was 1526 cm² per plant at 90 DAS and minimum observed leaf area was 473.2 cm² per plant.

Table 20a. LAI of *Sacciolepis* as influenced by stale seed bed technique

Treatments	45 DAS	90 DAS
Normal sowing	0.48	3.65
Stale seed bed (hoeing)	0.39	0.76
Stale seed bed (paraquat)	0.14	0.40
SEm	0.05	0.29
LSD (0.05)	0.15	0.95

Table 20b. Effect of stale seed bed technique on leaf area of *Sacciolepis* (cm²/plant)

Treatments	45 DAS	90 DAS
Normal sowing	231.1	1526.4
Stale seed bed (hoeing)	460.2	652.7
Stale seed bed (paraquat)	306.5	473.2
SEm	72.0	397.8
LSD (0.05)	NS	NS

Height of *Sacciolepis*

No significant effect on height was observed in different treatments at various stages. From the values given in Table 21, maximum height at 90 DAS observed was 117 cm in stale seed bed with paraquat spray and minimum height observed was 114.5 cm in normal seed bed.

Table 21. Height of *Sacciolepis* as influenced by stale seed bed treatment (cm)

Treatments	45 DAS	90 DAS
Normal sowing	46.9	114.5
Stale seed bed (hoeing)	62.8	117.6
Stale seed bed (paraquat)	54.8	116.1
SEm	3.89	5.32
LSD (0.05)	NS	NS

Number of inflorescence per plant

Significant effect of stale seed bed technique was noticed on the number of inflorescence per plant (Table 22). Maximum number of inflorescence was present in normal crop whereas stale seed beds recorded minimum number of inflorescence per plant.

Table 22. Effect of stale seed bed technique on the number of inflorescence per plant, No. of seeds per inflorescence and days to 50 per cent flowering of *Sacciolepis interrupta* (Willd.) Stapf.

Treatments	No. of inflorescence per plant	No. of seeds per inflorescence	Days to 50% flowering
Normal sowing	12.2	919.6	75.4
Satle seed bed (hoeing)	6.4	649.4	83.6
Stale seed bed (paraquat)	5.6	529.2	84.8
SEm	1.4	122.7	0.4
LSD (0.05)	4.6	NS	1.1

Days to 50 per cent flowering in *Sacciolepis*

Number of days required for flowering of 50 per cent of the population was significantly influenced by the method of sowing (Table 22). Normal seed bed favoured early flowering (75.4 days) while stale seed beds favoured late flowering (83.6 to 84.8 days). Both the stale seed beds were on par.

Number of seeds per inflorescence

There was no significant difference due to the effect of seed beds on the number of seeds per inflorescence. However, numerically maximum seed production was observed in normal seed bed (Table 22).

Nutrient uptake by *Sacciolepis*

N, P, and K uptake was highest in Sacciolepis present in normal crop whereas nutrient uptake by *Sacciolepis* in the stale seed beds were on par (Table 23a).

Table 23a. Nutrient uptake of *Sacciolepis* as influenced by stale seed bed technique (kg ha^{-1})

Treatments	45 DAS			90 DAS		
	N	P	K	N	P	K
Normal sowing	7.41	2.15	9.28	19.32	8.19	41.25
Stale seed bed (hoeing)	3.04	0.83	3.70	13.50	4.59	20.52
Stale seed bed (paraquat)	1.77	0.49	2.14	6.32	2.91	14.09
SEm	1.35	0.17	0.77	2.22	1.23	7.18
LSD (0.05)	4.40	0.56	2.52	7.25	4.01	NS

Nitrogen content was not significant at 90 DAS (Table 23b). At 45 DAS significantly higher N content was noticed in stale seed bed with hoeing. N content in *Sacciolepis* in normal seed bed was on par with stale seed bed with paraquat.

Phosphorus and potassium content showed no significant effect on all the seed beds at 45 DAS and 90 DAS. At 45 DAS, P content ranged from 0.25-0.27 per cent and at 90 DAS, it ranged from 0.29-0.36 per cent. Potassium content ranged from 1.21-1.25 per cent at 45 DAS and 1.23-1.59 per cent at 90 DAS.

Table 23b. Effect of stale seed bed on the nutrient content of *Sacciolepis* at 45 DAS and 90 DAS

Treatments	45 DAS			90 DAS		
	N (%)	P(%)	K(%)	N (%)	P (%)	K (%)
Normal sowing	0.69	0.25	1.24	1.30	0.36	1.59
Stale seed bed (hoeing)	0.81	0.27	1.25	1.09	0.29	1.31
Stale seed bed (paraquat)	0.54	0.26	1.21	0.96	0.29	1.23
SEm	0.05	0.11	0.09	0.29	0.02	1.11
LSD (0.05)	0.15	NS	NS	0.23	NS	NS

4.3.4 Economics of weed control

Economic analysis of the weed control treatments of the study is presented in Table 24.

Table 24. Economics of weed control treatments

Treatments	Value of produce (Rs.)	Cost of weed control (Rs.)	Total cost of cultivation (Rs.)	Benefit/ Cost ratio
Normal sowing + weed free	24562	7200	19418	1.26
Normal sowing + Oxyfluorfen @ 0.15 kg ha^{-1}	11731	4100	16318	0.72
Normal sowing + unweeded	6548	-	12218	0.54
Stale seed bed (hoeing) + weed free	31468	9950	22168	1.42
Stale seed bed (hoeing) + oxyfluorfen @ 0.15 kg ha^{-1}	22464	6850	19068	1.18
Stale seed bed (hoeing) + unweeded	10051	2750	14968	0.67
Stale seed bed (paraquat) + weed free	32457	9282	21498	1.51
Stale seed bed (Paraquat) + oxyfluorfen @ 0.15 kg ha^{-1}	19278	6180	18400	1.05
Stale seed bed (paraquat) + unweeded	12939	2080	14300	0.90

Price of paddy Rs.6/- per kg. Straw Rs.1.5/- per kg
Wages: Rs.110/- per man and Rs.70/- per woman
Norms for spraying : 0.2 ha/man, for hoeing : 0.04 ha/man
Cost of cultivation excluding weeding: Rs.12218/-
Cost of oxyfluorfen (Goal 23.5 EC) Rs.1640/- per litre
Cost of paraquat (Gramaxone 20 EC) Rs.260/- per litre

Stale seed bed with paraquat when maintained weed free gave the highest economic return per rupee invested (1.51) which was followed by weed free condition in stale seed bed with hoeing (1.42). Weed free condition in normal sowing recorded higher benefit cost ratio than application of oxyfluorfen in paraquat applied stale seed bed. Application of oxyfluorfen in normal seed bed, cultivated stale seed bed and all unweeded treatments worked out to be loss.

DISCUSSION

5. DISCUSSION

Experiments were conducted to study the emergence pattern of *Sacciolepis interrupta* (Willd.) Stapf. and to test the effectiveness of stale seed bed technique in the management of the weed. The results obtained are discussed in this chapter.

5.1 Emergence of *Sacciolepis interrupta*

Emergence pattern of *Sacciolepis* showed that majority of the weed (87.1%) germinated during the first two weeks after the initial ploughing consequent to the receipt of pre-monsoon showers and emergence ceased after four weeks provided no subsequent soil disturbance was made (Table 2a). When the land was not ploughed, there was no emergence even after the receipt of rain. Seed germination, however, continued when the soil was ploughed again (Table 2b). The results showed that tillage had an influence on the emergence of the weed. Tillage might be stimulating germination by redistributing seeds to positions favourable for germination and can also be by seed scarification. This has been reported by Dyer (1995). Budd *et al.* (1979) reported maximum emergence of seeds of *Commelina benghalensis* when buried at zero cm and minimum emergence when buried at eight cm depth. Zimdahl et al. (1988) reported that 40-50 per cent of weed emergence occurred within six weeks of tillage in upland and lowland rice soils. Bond and Baker (1990) reported emergence of 50 per cent of weed population within 6 weeks of tillage when conditions were moist. It seems temperature had not much influence on the emergence of *Sacciolepis* as there was not much variations in weekly data during the brief period of emergence studied (Appendix-I).

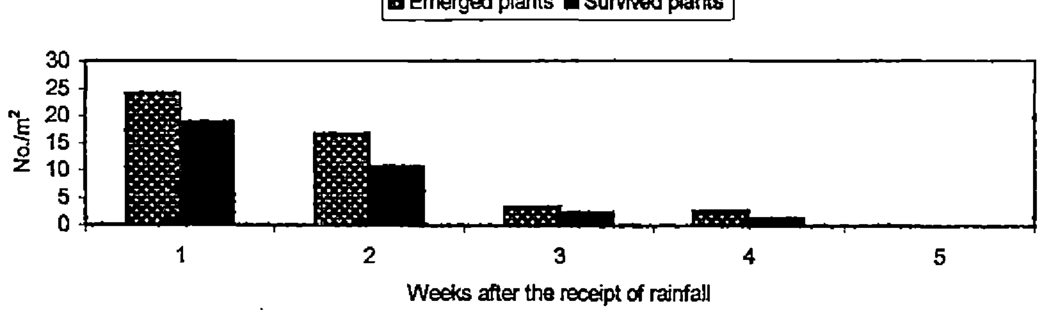

Fig.4. Field emergence and survival of *Sacciolepis interrupta*

The mortality percentage was lower for the early emerged seedlings and much higher for those appearing at the end of the emergence period (Fig.4). The major reason for the low mortality of early emerged seedlings might be due to the initial growth and vigour of the seedlings under favourable conditions without any competition. Later emerging seedlings faces severe intra-specific competition. The result supports the possibility of delaying sowing date as a method of control, which can reduce potential infestation of *Sacciolepis interrupta* (Willd.) Stapf.

5.2 Germination studies

No appreciable germination was obtained in the study (Table 3). However, the germination pattern showed that, seeds remained dormant for initial six to seven months. Germination commenced by the month of March and attained a peak during June and July.

Dyer (1995) reported that in addition to dormancy cycling under field conditions, some endogenous rhythm is established that may persist in seeds removed from the field and stored under controlled conditions. Whether there exist an endogenous rhythm persisting in seeds removed from fields and stored in controlled conditions need further investigation. As Dyer (1995) pointed out, exposure to light breaks dormancy in many species, especially small seeded weeds. To test this for *Sacciolepis*, germination may also be attempted in artificial light conditions.

Annual periodicity of dormancy or germination behaviour has been documented for seeds of many annual plants (Karssen, 1982). Seeds of rough stalk blue grass exhibited a periodicity of germination that persisted for at least 15 months after field collection when stored at 23°C (Froud-Williams *et al.*, 1986).

5.3 Competitiveness of *Sacciolepis interrupta* modified by stale seed bed technique

5.3.1 Crop growth

Delaying the seeding of rice by two weeks through stale seed bed technique affected all the crop growth characters studied. Stale seed bed plots showed an increase in leaf area index (Table 4), height (Table 5), dry matter production

(Table 6) and tiller production of rice (Table 7) at all the stages compared to the plots which were seeded without stale bed immediately after the initial receipt of rainfall. The differences are discernable even at 15 DAS. The differences at 45 DAS and 90 DAS can be ascribed to competition from weeds as is evident from Table 13,14, and 18. The favourable effects on crop growth at 15 DAS, however, may not be due to the effect of weed competition alone as the weed growth parameters were non-significant. The differences at this stage may be due to the amount of rainfall received during the two weeks immediately after seeding. The crop which was seeded at normal time (sown on 22-4-99) received 5.2 mm and 35.0 mm rainfall during the first and second week after sowing. However, the stale seed bed crop (sown on 7-5-99) received 37.0 and 51.6 mm rains during the first and second week after sowing. The favourable effects of sufficient soil moisture on crop growth need no emphasize.

Weeds, in general compete with crops for nutrients, moisture, light and thereby affect crop growth and development and finally the yield. In the present experiment, though *Sacciolepis* plants in the stale seed beds showed higher unit biomass at 15 DAS than normal sowing, by 45 DAS, the initial advantage of *Sacciolepis* was lost (Table 19b). At 15 DAS, itself though the per unit biomass was lesser, number of *Sacciolepis* per unit area was higher in normal sown plots (Table 13). At the same time, crop which has an initial advantage in stale seed bed by way of higher unit biomass maintained its sway competiting effectively with the number of *Sacciolepis* in the stale seed beds. In addition to per unit number of *Sacciolepis*, biomass per unit area was also less in stale seed beds by 45 DAS and 90 DAS.

The LAI, height, number of tillers and dry matter production of crop at 15 DAS was the least in oxyfluorfen applied plots. Phytotoxic effects due to oxyfluorfen was already reported in rice. Mukhopadhay and Mandal (1982) reported initial yellowing which recovered later in about 2-3 week. A slight yellowing was noticed in the present experiment also (visual observations – data not presented) which recovered later. Initial low growth parameters in oxyfluorfen applied plots can be best ascribed to phytotoxicity of oxyfluorfen as explained earlier.

LAI was the highest in weed free plots(Table 4). LAI is an important measure of potential photosynthetic area and thus of the growth capability (Potter and Jones, 1977). LAI of oxyfluorfen applied plot improved considerably by 45 DAS. Though there was no significant difference in LAI between weed free, unweeded and *Sacciolepis* plots at 15 DAS, the differences became quite evident by 45 DAS. At 45 DAS, *Sacciolepis* attained more height than rice (Fig.5). This might have reduced the light interception by the crop and hence might have inversely affected the leaf area development by the crop. As Aldrich (1984) stated, leaf and height characteristics together determine the relative competitiveness of a species for light. Reduced leaf area development of rice canopy due to reduced light intensity was reported by Venkateswarlu (1977). Reduced plant height due to competition was reported by Sreedevi (1979).

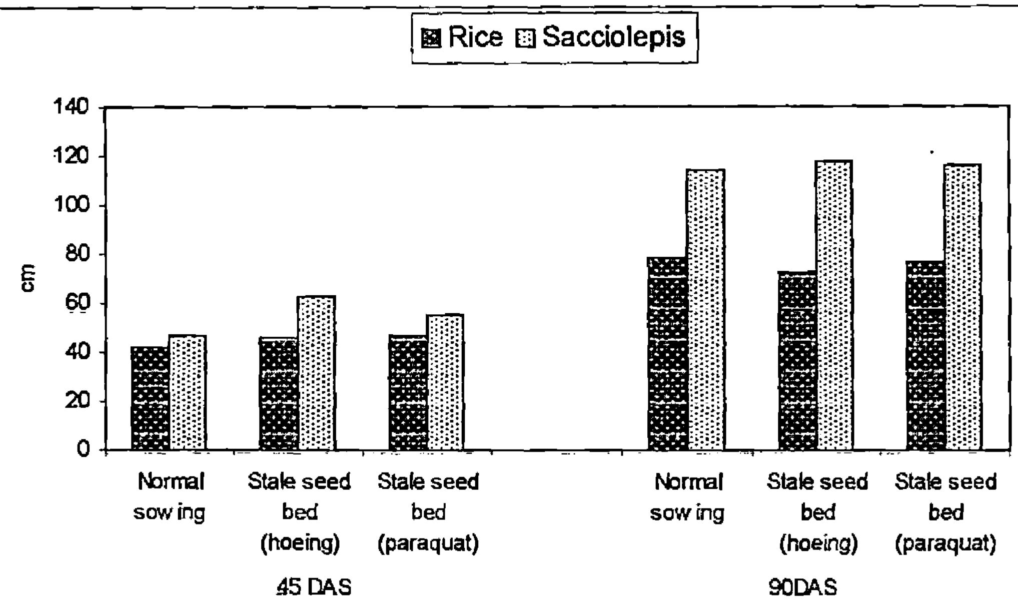

Fig.5. Effect of stale seed bed on the height of rice and *Sacciolepis*

Competition of *Sacciolepis* reduced the number of tillers too(Table 7). Maximum number of tillers was observed in weed free conditions. Reduction in the number of tillers due to *Sacciolepis* competition was reported earlier too (AICRP-WC, 1997). Sudhakara and Nair (1986), Ravindran *et al.* (1978) and Sukumari(1982) reported a reduction in tiller production of rice due to weed competition.

Stale seed bed crop took only 74 days to attain 50 per cent flowering compared to 81 days in the normal crop(Table 8). Faw and Johnson (1975) reported early flowering due to delayed planting. Kang and Hue (1976) also observed prolonged growing period and longer delay in earing due to early planting.

5.3.2 Yield components and yield

Among the yield components studied, number of panicles per square meter and percentage of filled grains were higher in stale seed bed plots (Table 9). A reduction in the number of panicles per square meter and filled grains per panicle in unweeded plots was reported by Kumar and Gautam (1986). The results of the present study also followed the same trend. In the normal crop, comparatively higher incidence of rice bug attack was noticed due to its early flowering and that there was not many crops of the same age in the locality. However, the pest attack was kept under check by timely control measures.

With respect to competition levels, the number of panicles per square meter, number of grains per panicle and percentage of filled grains were the highest in weed free plots (Table 9). The presence of weeds to varying degrees in other plots reduced these yield contributing characters. Though not significant, 1000 grain weight was also the highest in weed free plots. Competitive effects of weeds on yield components of rice have been reported by many workers. A reduction in the number of panicles due to weed competition was reported by Noda *et al.* (1968), Ravindran *et al.* (1978), Kumar and Gautam (1986) and Mishra *et al.* (1989). Adverse effects on the number of grains per panicle was also reported (Ravindran *et al.*, 1978; AICRP-WC, 1997). The favourable effects of weed control on the number of filled grains was reported by Kumar and Gautam (1986) and Jayasree (1987) and the effects on 1000 grain weight by Ravindran *et al.* (1978), Mishra *et al.* (1989) and Azad *et al.* (1990).

Maximum grain as well as straw yield was obtained in stale seed bed with paraquat (Table 11 and Fig.6). Weed free conditions during germination and initial growth have provided better start for the crop plant and have rendered the ability to withstand the more competitive weed species. Stale seed bed with hoeing though recorded more number of weeds, have maintained similar grain yield with chemical seed bed. Slight hoeing might have provided better soil aeration which inturn favoured early growth as is evident from the data on LAI (Table 4) and dry matter production (Table 6).

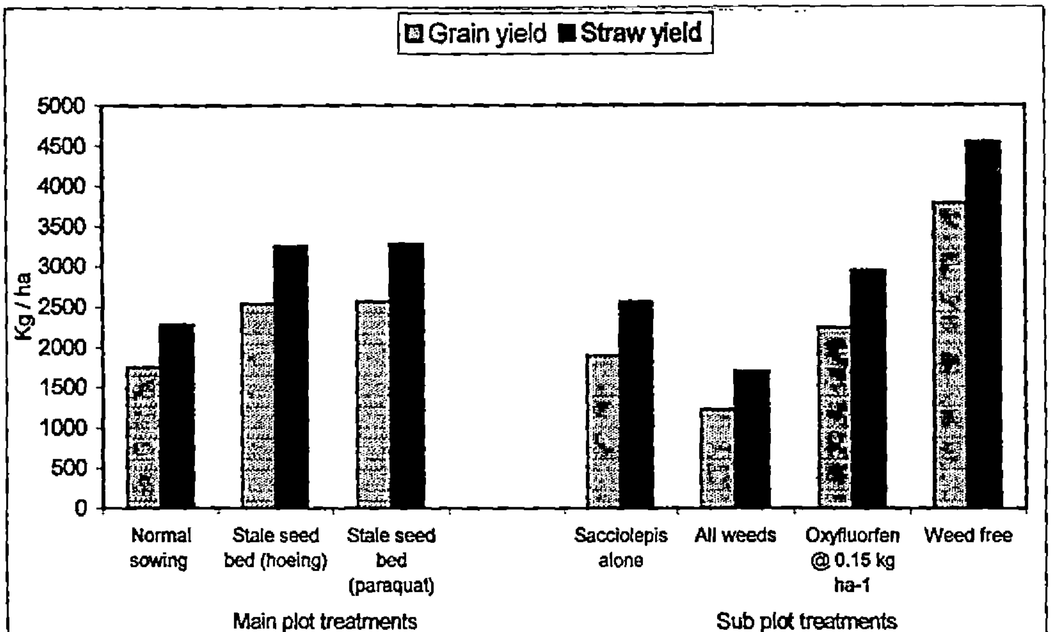

Fig.6. Grain and straw yield of rice as influenced by different treatments

As Ampong-Nyarko and DeDatta (1991) stated, competition occurs when one of the limiting resources fall short of the combined requirements of rice crop and weeds. Rice yields are greatly reduced when shading occurred at early growth stages and via stress from water shortage at any stage of crop development.

The lowest grain yield in unweeded plot might be due to the high competition for nutrients, light, water and space resulting in severe set back on growth and yield of the crop.

Sacciolepis competition also showed reduction in grain yield by 49.9 per cent. Yield reduction due to *Sacciolepis* by more than 40 per cent was reported by AICRP-WC (1997).

Yield reduction due to weed competition have been reported by Vaishya *et al.* (1992), Mandal (1990), AICRP-WC (1992). Ampong-Nyarko and DeDatta (1991) reported total crop loss due to weeds in uplands.

Yield components determine the final yield. Yield can be limited by either the supply of assimilates (source) during grain filling or by the number and capacity of kernels to be filled (sink) or by source and sink simultaneously (Fisher, 1983; Venkateswarlu and Visperas, 1987; Evans, 1993). In the present study, both source and sink were limited because of weed competition as is evident from the result of LAI (source) and dry matter production and various yield components (sink). After anthesis, the head can act as both a sink and a source.

Phytosynthates deposited in grain come from three sources viz., current assimilates by leaf photosynthesis, current assimilates from non-leaf parts and remobilization of pre-anthesis assimilates deposited in other plant organs (Evans *et al.*, 1975; Evans and Wardlaw, 1976; Gardner *et al.*, 1985). In general, as Gardner *et al.* (1985) reported, the contribution of pre-anthesis assimilates is 25 per cent, current leaf and stem photosynthesis 45 per cent and head photosynthesis 30 per cent towards grain yield in cereals. In the present study, shading due to tall *Sacciolepis* might have adversely affected the production of current assimilates as is evident from height in the later stages. It aggravated the problem as the size of source and sinks were already limited due to competitive effects of weeds. The biological yield as proposed by Nichiporovich (1956) represent the total dry matter accumulation of a plant's system (minus root weight because of the difficulty in obtaining these values). It includes both straw and grain yield. The proportion of biological yield represented by economic yield has been called the harvest index, the co-efficient of effectiveness or the migration co-efficient (Gardner *et al.*, 1985). A higher HI indicates efficient partitioning of dry matter to grains.

Though there was significant influence on the grain and straw yield due to stale seed bed adoption, harvest index was not affected (Table 11). Among subplots, highest harvest index was recorded in weed free plots. Stale seed bed technique showed an increase in biological yield and both biological yield and HI were reduced by weed competition. In weedy situations, partitioning of assimilates to grains is affected. The decrease in irradiance tends to decrease HI (Bugbee and Salisbury, 1988). In a rice crop, shading by the tall *Sacciolepis* plants and other weeds can reduce light penetration and availability of sunlight to rice leaves especially in the later stages.

5.3.3 Nutrient uptake by the crop

The results on the nutrient uptake by the crop showed that where the competition from weeds was less, the nutrient uptake by the crop was higher (Table 12 and Fig.7). As there was not much variation in the percentage content of nutrients (Appendix-III) between treatments, the uptake of nutrients followed almost the same trend as that of grain and straw yield. Similar results of increased nutrient uptake by rice with lesser weed competition were reported by Biswas and Sattar (1991) and Varughese (1996).

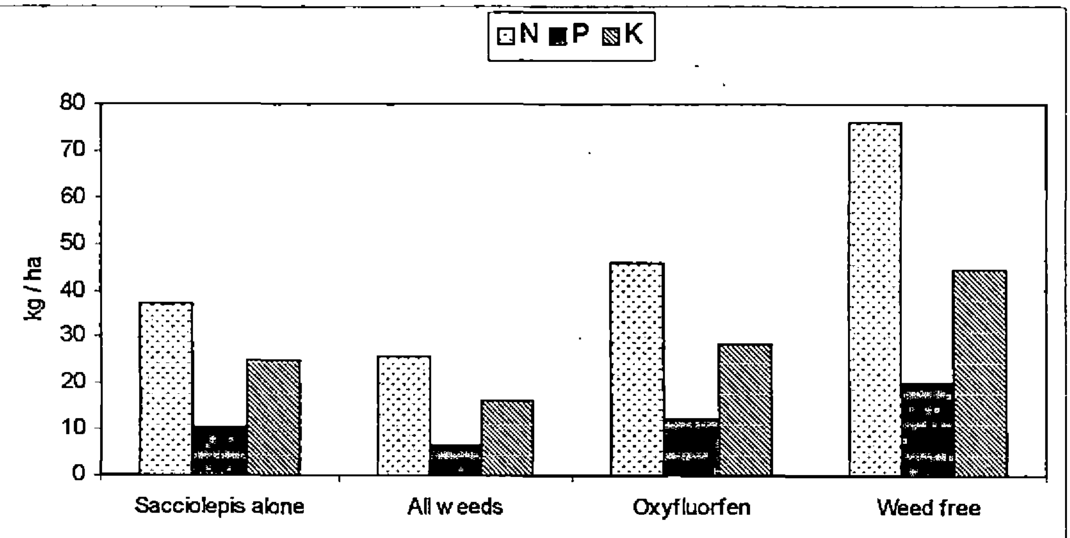

Fig.7. Effect of weed competition on nutrient uptake by the crop

5.3.4 Weed count and weed biomass

Total weed count and weed biomass was higher in normal seed bed than in stale seed bed (Table 14 and 15). At 90 DAS, the weed count was high in stale seed bed with hoeing than in stale seed bed with paraquat (Fig.8). In stale seed bed, initial weed flushes were destroyed and crop was raised in weed free seed beds. Initial weed free condition provided a good start for the crop plants and enabled the crop to smother or withstand the later emerging weed flushes. Thus the weed stand was reduced in stale seed beds. Comparatively high number of weeds in the stale seed bed with hoeing may be due to redistribution of weed seeds from the lower soil layer to the most favourable soil surface for germination. Nai-Kin Ho (1996) observed that chemical methods are superior to cultural methods as they do not bring more weed seeds to the soil surface. Hosmani (1991) reported reduced weed intensity in late sown kharif crops than early sown kharif crops. Favourable effects of stale seed bed technique in reducing weed intensity were reported by many workers (eg., Ampong – Nyarko and De Datta, 1991; Bruff and Shaw, 1992; Shaw, 1996).

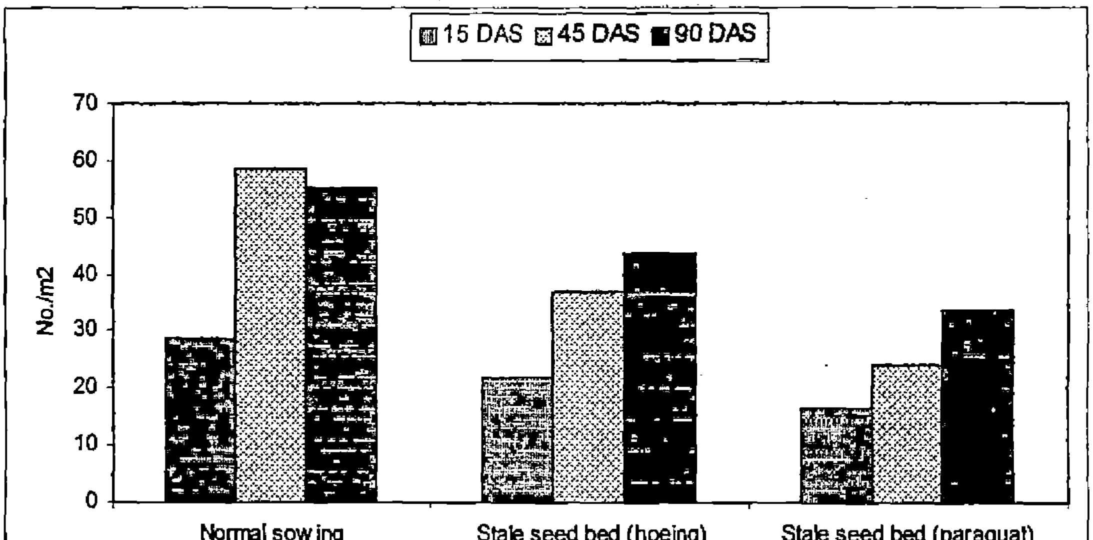

Fig.8. Effect of stale seed bed on total weed count

Though oxyfuorfen is effective in controlling *Sacciolepis* (Table 13), broad leaf weeds (Table 17) and sedges (Table 18) by 15 DAS, it seems it is not so efficient on other grassy weeds. However, total weed count in oxyflourfen applied plots was reduced considerably at 15 DAS when compared to unweeded plots. However, by 45 DAS and 90 DAS, weeds came up in this plots too, that in number was almost similar to unweeded plots. In terms of total biomass of weeds, it was still the best after weed

Plate.1.A general view of unweeded plots

Compared to normal sowing (above) weed competition is substantially reduced in stale seed bed plots (below).

free plots. Many research reports have favoured one hand weeding following pre-emergence application of oxyflourfen to have better weed control efficiency in dry seeded rice (Sreedevi and Thomas, 1993; Varughese, 1996).

5.3.5 Observations on *Sacciolepis*

The number of *Sacciolepis*

The count of *Sacciolepis* was less in stale seed beds than normal sowing (Fig.9). Paraquat application brought no new seeds to the surface and hence reduced subsequent emergence of the weed. *Sacciolepis* population was reduced by 85 per cent in paraquat applied plots at 15 DAS. Hoeing might have brought more new seeds to the surface and increased weed emergence than in chemical stale seed bed. As only slight disturbance was made, only very less emergence of new *Sacciolepis* was observed in chemical stale seed bed. The effectiveness of stale seed bed in the management of *Sacciolepis* is confirmed from the results obtained.

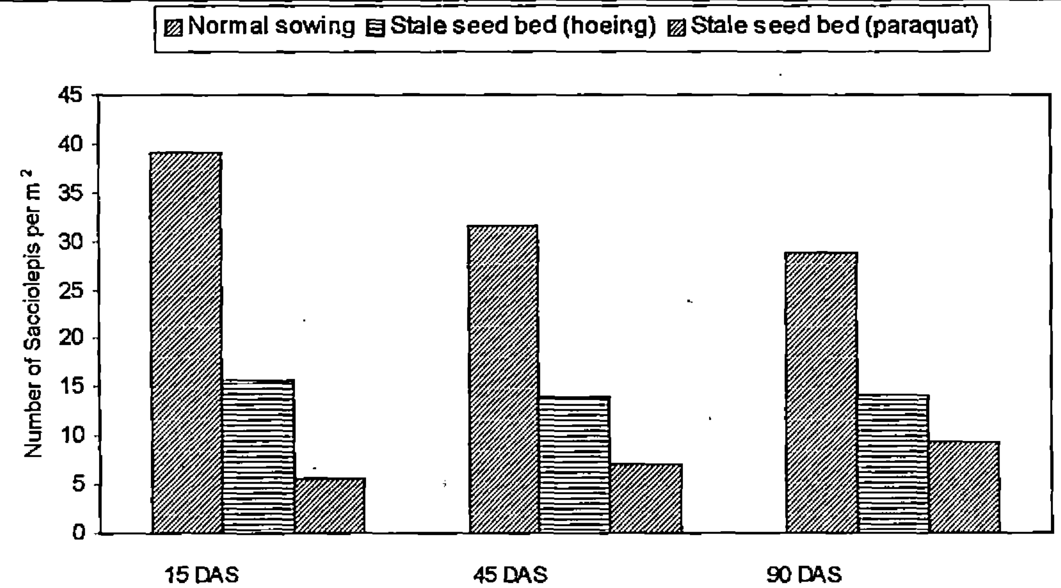

Fig.9. Effect of stale seed bed technique on the No. of *Sacciolepis* per m^2

Oxyflourfen treated plot showed remarkable decrease in the number of *Sacciolepis* (Table 13). Thomas and Sreedevi (1993) obtained 100 per cent efficiency in controlling *Sacciolepis* by spraying oxyflourfen.

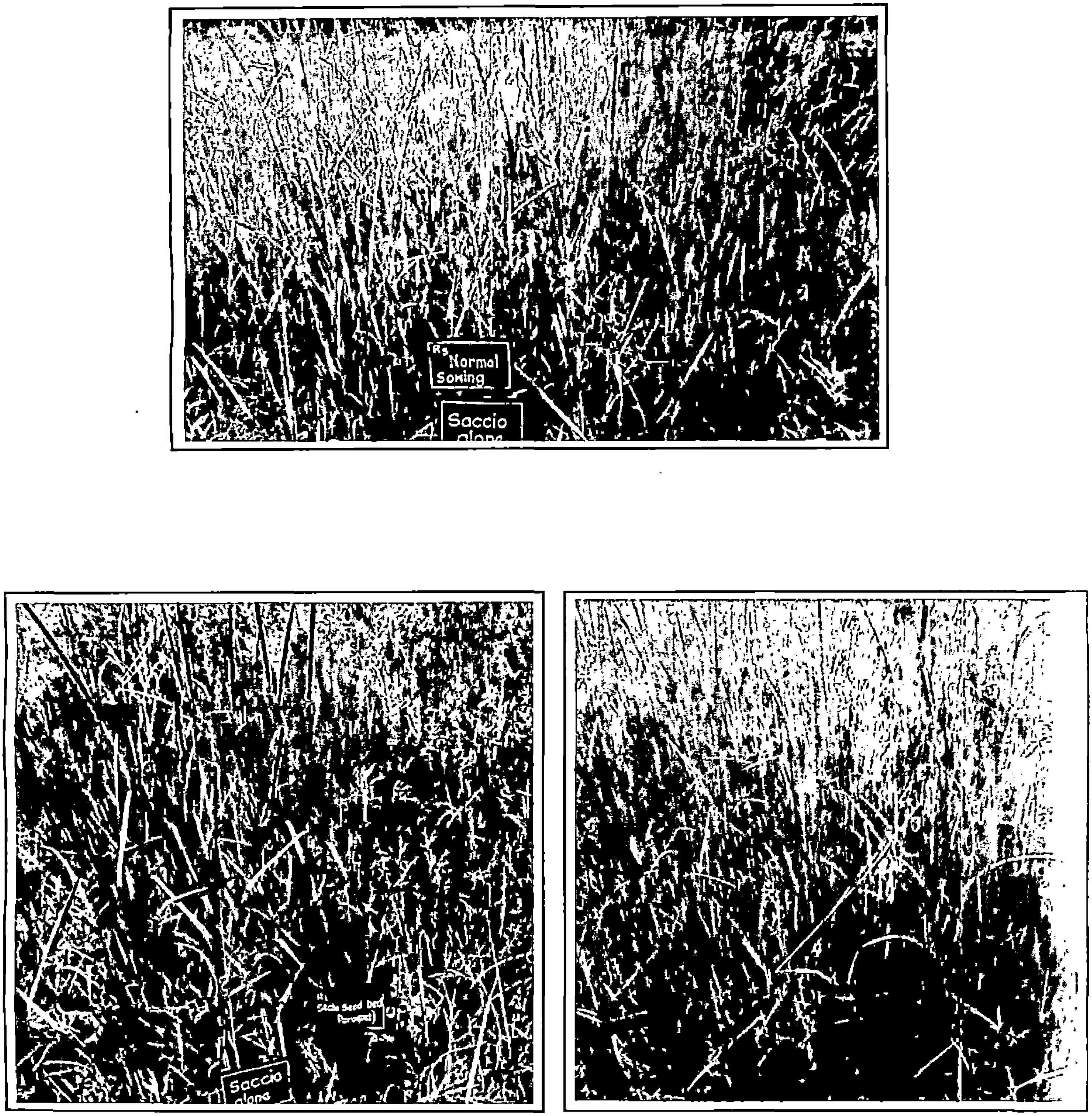

Plate.3. Stale seed bed technique reduces the number of *Sacciolepis interrupta* in semi-dry rice

Compare the pictures of increased population of *Sacciolepis* in normal sowing (above) and reduced population in 'stale seed bed' plots (below).

Growth characters of *Sacciolepis*

LAI of *Sacciolepis* was higher in normal seed bed (Table 20a). More number of *Sacciolepis* per unit area and more number of tillers per unit area account for maximum leaf area index in the normal seed bed.

Number of panicles of *Sacciolepis* was more in normal plot as compared to stale seed bed (Table 22). Simultaneous emergence of *Sacciolepis* along with the crop and better competing ability of the weed might have developed more number of tillers per plant and hence more number of panicles per plant. Number of grains per panicle was also more in normal seed bed.

Stale seed bed technique favours late sowing indirectly depriving the *Sacciolepis* the benefit of growing during the most favourable period. This might be the reason for less number of inflorescence per plant and less number of seeds per inflorescence. In addition, as the 50 per cent flowering in *Sacciolepis* in the stale seed bed is delayed (Table 22), addition of more number of mature seeds in the seed bank may also be prevented.

There was no further germination of *Sacciolepis* after 15 DAS as is evident from the Table 13 in the case of normal sown crop. In fact, there was some mortality of *Sacciolepis* at 45 DAS and 90 DAS because of intraspecific competition. However, there was no observed mortality of *Sacciolepis* in stale seed bed plots probably due to less intra specific competition.

SUMMARY

6. SUMMARY

Sacciolepis interrupta (willd.) Stapf. is a serious weed of semi-dry rice in Kerala. An investigation titled 'Emergence and competition of *Sacciolepis interrupta* (Willd.) Stapf. in semidry rice' was conducted focussing on the emergence, growth and management of this weed. The objectives were to study the emergence pattern of *Sacciolepis* and its relationship with temperature and rainfall, estimate the losses caused by *Sacciolepis* and test the feasibility of stale seed bed technique for the management of the weed. Economic analysis of different treatments was also done.

The study was undertaken in three parts to achieve the objectives.

Expt. 1. Field emergence of *Sacciolepis interrupta* (Willd.) Stapf.

The emergence pattern of *Sacciolepis* revealed that 87 per cent of the weed emerged during the first two weeks after the initial ploughing given after the receipt of pre-monsoon showers. Tillage influenced the emergence of *Sacciolepis*.

Expt. 2. Germination studies

Germination studies were conducted in petridishes at monthly intervals using seeds collected during July, 1998. No appreciable germination percentage was obtained during the study. However, the germination study revealed that the seeds remain dormant for the initial 6-7 months. Germination commenced by the month of March and attained a peak during June and July.

Expt. 3. Competitiveness of *Sacciolepis interrupta* (Willd.) Stapf modified by stale seed bed technique

Competition studies were conducted during the first crop season (early *Kharif*) of 1999 using split plot arrangement in randomised block design. The analysis of the impact of stale seed bed practice on the control of *Sacciolepis* showed that stale seed bed considerably reduced the weed count as well as the weed dry matter production. Stale seed bed increased the grain yield of the crop. The yield attributes

like number of panicles per unit area, number of grains per panicle and fertile grains per panicle were highest in stale seed bed plots. Among the stale seed bed treatments, stale seed bed with paraquat application proved to be better in reducing the weed count and weed dry matter production. Stale seed bed also favoured the tiller production, dry matter production and nutrient uptake of rice.

Competitive interactions from *Sacciolepis* reduced the leaf area index, height and dry matter production of rice. The grain and straw yield was adversely affected by *Sacciolepis*. Yield reduction due to *Sacciolepis* was worked out to be 50.1 per cent.

The application of oxyfluorfen @ 0.15 kg ai ha^{-1} was found to be efficient in controlling *Sacciolepis*. Compared to normal sowing, Oxyfluorfen spray on stale seed beds was found to be more effective. However, oxyfluorfen application alone could not control the growth of other grasses, especially *Echinochloa colona* and sedges beyond 15 DAS. Though oxyfluorfen was found to be phytotoxic to rice at early stages, the crop recovered soon.

From the study, it could be concluded that the practice of stale seed bed technique is an efficient tool for the management of *Sacciolepis interrupta* (Willd.) Stapf. in semi-dry rice. Stale seed bed with paraquat was on par with stale seed bed with hoeing with respect to grain and straw yields. Among the subplots, weed free treatment was significantly superior (3782.1 kg) to others followed by oxyfluorfen application (2236.5 kg). Pre-emergence application of oxyfluorfen reduced *Sacciolepis* problem but it could not control other weeds beyond 15 DAS. As the oxyfluorfen spraying prevented germination of weeds in the beginning, it could be recommended as a pre-emergence treatment to be followed by one handweeding. Stale seed bed with paraquat maintained weed free gave the highest economic return (Rs. 32457/-) followed by stale seed bed with hoeing (Rs. 31468/-).

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* Originals not seen

APPENDICES

APPENDIX-I

WEEKLY WEATHER DATA FOR THE FIRST CROP SEASON 1999

Month	Meteorological week	Mean Temperature (°C)		Mean Relative Humidity (%)		Sunshine (hrs/day)	Rainfall (mm/week)	Mean evaporation (mm)
		Max	Min	Morning	Afternoon			
April	2/4-8/4	34.9	24.5	90	55	7.8	26.2	5.7
	9/4-15/4	33.2	25.8	86	59	7.4	0.0	4.6
	16/4-22/4	33.1	26.2	89	62	4.6	7.6	3.9
	23/4-29/4	32.0	25.9	90	59	4.2	5.2	3.6
	30/4-6/5	33.6	24.8	89	59	6.3	35.0	4.4
May	7/5-13/5	31.0	25.2	90	66	6.4	37.0	3.1
	14/5-20/5	30.4	25.1	80	74	5.5	51.6	3.2
	21/5-27/5	29.0	23.8	95	85	2.6	221.2	2.9
	28/5-3/6	29.8	22.8	96	75	5.0	143.2	3.1
June	4/6-10/6	29.1	22.8	94	81	4.8	134.7	3.2
	11/6-17/6	28.4	22.7	95	81	1.8	170.9	2.5
	18/6-24/6	29.6	23.2	95	76	5.1	114.8	2.9
	25/6-1/7	30.9	23.0	92	67	8.9	21.6	3.8
July	2/7-8/7	29.6	23.1	95	80	3.7	114.7	2.9
	9/7-15/7	29.0	22.9	96	76	3.1	124.6	2.6
	16/7-22/7	26.9	22.8	97	92	0.5	326.5	1.8
	23/7-29/7	27.7	23.7	95	82	1.1	182.8	1.9
	30/7-5/8	28.7	23.3	95	84	2.7	194.1	2.4
Aug	6/8-12/8	29.5	23.7	95	74.9	5.2	121.5	3.0
	13/8-19/8	30.6	24.1	93	69	7.5	8.9	3.5
	20/8-26/8	30.0	23.6	93	69	6.9	3.2	3.6
	27/8-2/9	30.0	23.6	93	71	5.3	7.1	2.9

APPENDIX-II

DETAILS OF FIELD OPERATIONS

Operations	Date	
	Normal sowing	Stale seed bed
Ploughing	12/4/99	12/4/99
Layout	15/4/99	15/4/99
Levelling	16/4/99	16/4/99
Hoeing	-	06/5/99
Paraquat application	-	05/5/99
Dibbling seeds	22/4/99	07/5/99
Fertilizer application	22/4/99	07/5/99
Oxyfluorfen spraying	25/4/99	10/5/99
Thinning and gap filling	12/5/99	02/6/99
Weeding	05/5/99	20/5/99
	20/5/99	12/6/99
	30/6/99	02/7/99
	11/7/99	
Irrigation	26/6/99	26/6/99
Top dressing	25/5/99	10/6/99
Insecticide spraying	01/6/99	01/6/99
	11/7/99	11/7/99
	26/7/99	26/7/99
Harvest	18/8/99	23/8/99
Thresing and winnowing	18/8/99	23/8/99

APPENDIX III

MEAN PER CENT CONTENT OF NPK IN GRAIN AND STRAW

Treatments	Grain			Straw		
	N	P	K	N	P	K
Normal sowing	1.24	0.38	0.26	0.72	0.19	0.73
Stale seed bed (hoeing)	1.03	0.34	0.25	0.70	0.15	0.81
Stale seed bed (paraquat)	1.13	0.33	0.25	0.70	0.12	0.77
Sacciolepis alone	1.02	0.36	0.26	0.71	0.15	0.77
All weeds	1.15	0.34	0.25	0.70	0.15	0.77
Oxyfluorfen @ 0.1 kg ha^{-1}	1.16	0.34	0.25	0.70	0.16	0.78
Weed free	1.16	0.36	0.26	0.71	0.16	0.77

EMERGENCE AND COMPETITION OF 'POLLA'

[*Sacciolepis interrupta* (Willd.) Stapf.]

IN SEMI-DRY RICE

By

RENU, S.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

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ABSTRACT

Sacciolepis interrupta (Willd.) Stapf. is a serious weed of the semi dry rice in Kerala. An investigation focussing on the emergence pattern and growth characteristics of *Sacciolepis* and its management were undertaken at the Agricultural Research Station, Mannuthy during the early *Kharif* of 1999.

Sacciolepis interrupta was found to emerge during the first few weeks after the initial ploughing followed by pre-monsoon showers. Majority of the weed seedlings (87%) emerged during the first two weeks. The emergence pattern supports the possibility of practicing a stale seed bed. in the management of the weed. Seeds collected during July 1998 remained dormant for initial six to seven months. The seed germination commenced by the month of March and attained a peak during June and July.

The study on the competitiveness of *Sacciolepis interrupta* modified by stale seed bed technique was conducted during the first crop season using split plot arrangement in randomised block design (early *Kharif*) of 1999. The study revealed that competition from *Sacciolepis* alone could reduce the rice grain yield by 50.1 per cent. The *Sacciolepis* compete with the crop and reduced the height, LAI, tiller production and biomass production of the crop.

Adoption of stale seed bed method reduced the competition from all weeds including *Sacciolepis*. Stale seed bed with paraquat application was found to be better than stale seed with hoeing. Application of oxyfluorfen @ 0.15 kg ai ha^{-1} as pre-emergence spray though reduced the problem of *Sacciolepis* in the semi-dry rice, could not prevent germination of other weeds beyond 15 DAS. However, as pre-emergence application of oxyflourfen prevented germination of all type of weeds in the beginning, it could save one hand weeding.

From the study, it could be concluded that the practice of stale seed bed technique is an efficient tool for the management of *Sacciolepis interrupta* in semi-dry rice. The practice was found to be economically viable also.