Indian Journal of Weed Science 41(3&4) : 142-147, 2009

Effect of weed management and crop establishment methods on weed dynamics and productivity of rice

Jai Kumar, Anil Kumar and B.C. Sharma
Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu (Jammu and Kashmir)
E-mail : anillau@gmail.com

ABSTRACT

A field experiment was conducted on sandy loam soil at Research Farm of Sher-e-Kashmir University of Agricultural Sciences & Technology, Chatha, Jammu during the years 2006 and 2007 to study the effect of weed management and crop establishment methods on weed dynamics and grain yield of rice. The results revealed that among weed management methods, mechanical hoeing using conoweeder (at 15 and 30 Days after transplanting, (DAT) significantly reduced the total weed population and dry weight of weeds and recoded higher grain (4256 and 4393 kg/ha) and straw yields (5381 and 5677 kg/ha) than weedy check , but was statistically at par with fenoxaprop-p-ethyl (0.06 kg/ha, 20 DAT) *fb* 1 HW at 30 DAT, followed by metsulfuron methyl *fb* chlorimuron ethyl (0.004 kg/ha, 20 DAT) *fb* 1 HW at 30 DAT, fenoxaprop-p-ethyl (0.06 kg/ha, 20 DAT) and metasulfuron methyl *fb* chlorimuron ethyl (0.004 kg/ha, 20 DAT). However, metsulfuron methyl *fb* chlorimuron ethyl (0.004 kg/ha) was found to be more effective against broad leaved weeds and very little to sedges, thus failed to control major grassy weeds during the experimentation. Among the establishment methods of rice, conventional and system of rice intensification (SRI) methods were at par with respect to effective tillers, panicle length, grains/panicle, 1000 grain weight, grain yield, straw yield and harvest index. Significantly highest and lowest grain yields were obtained in case of weed free (4662 and 4745 kg/ha) and weedy check (3075 and 3140 kg/ha*) *treatments, respectively during both the years.

Key words : Weed management, Crop establishment methods, Productivity, Rice

Rice is grown mainly as a transplanted crop in sub-tropical irrigated belts of Jammu, usually planted in the month of July which necessitates the nursery raising one month earlier, starting from 1st week of June. In many regions farmers fail to undertake timely transplanting which results in reduction of rice yield. The alternative to this could be different method of rice establishment which would allow 10-15 days earlier transplanting than conventional method thereby allowing timely planting of succeeding wheat crop (Uphoff 2005). The other major constraint is the weed problem in rice. The problem of extensive weed incidence during early stages of rice crop growth cannot be undermined which competes with crop plants for moisture, nutrients, light, space and other growth factors. This crop-weed competition leads to significant yield losses to the tune of 35-55 per cent in transplanted rice (Gautam and Mishra 1995, Purushamam 1996). Recent estimates showed that average reduction in yield due to weeds varied from 12 to 72% depending upon weed flora and the extent of competition offered by weeds to the crop. Hand weeding, though efficient yet is a costly affair and is difficult due to continuous rain during *kharif* season. Some times, application of pre-emergence herbicides also is not sufficient to give effective weed control.

For keeping weed population under threshold level, there is a need for an evaluation of appropriate weed control methods over and above the existing practice with flexibility in various options of chemical and mechanical methods as routine weed control strategy that gives rise to emergence of new weed species over a period of time. Hence, agronomical manipulations such as establishment techniques with weed management may offer an effective option for better control of weeds in rice, thereby enhancing rice yield. In cognizance of the above, the present study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted at Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu to examine the weed and crop growth under various weed management and crop establishment techniques of rice during *kharif* seasons of 2006 and 2007. The soil of the experimental site was sandy loam in texture having a pH of 8.1, low in organic carbon and nitrogen, medium in

available phosphorus and potassium. The experiment was laid out in factorial randomized block design with fourteen treatment combinations, comprising of seven weed management practices, *viz.,* weedy check, weed free, metasulfuron methyl *fb* chlorimuron ethyl (0.004 kg/ha, 20 DAT), metasulfuron methyl *fb* chlorimuron ethyl (0.004 kg/ha, 20 DAT) *fb* 1 HW at 30 DAT, fenoxaprop-p-ethyl (0.06 kg/ha, 20 DAT), fenoxaprop-p-ethyl (0.06 kg/ha, 20 DAT) fb 1 HW at 30 DAT, mechanical hoeing using conoweeder (15 and 30 DAT) and two establishment methods, *viz.,* conventional transplanting (27 days old seedling and 2-3 seedlings/hill) and system of rice intensification (SRI) (10 days old seedling and 1 seedling/hill). However, split plot design was followed in succeeding wheat crop.

Two types of nurseries were raised for the rice crop. In case of conventional technique, raised beds of 10 x 1.25 m were prepared with the help of tractor and spade. The seed of *PC-19* variety at 40 kg/ha was sown 10 cm apart in rows, whereas for raising seedlings under SRI, four raised beds of 3.0 x 1.25 m dimension were prepared by spade with a water channel of 0.5 m width made around consisting of alternate layers of soil and well decomposed FYM of 1.5" and 1" thickness respectively, until it was 6" above the ground level having final layer of 2.5" thickness. On these beds pre-germinated seeds at 8 kg/ha were broadcasted and the beds were mulched for first three days to avoid bird damage. Beds of both the nurseries were irrigated frequently to maintain adequate soil moisture. Transplanting of rice crop was done manually on 7th and 10th of July during *kharif* seasons of 2006 and 2007, respectively for both the establishment techniques. In case of conventional technique, 27-28 days old seedlings and 2-3 seedlings/hill were planted in normal spacing of 20 x 10 cm whereas in case of SRI, 10 days old seedlings were removed carefully along with soil from the nursery bed without damaging the root zone and then single seedling/hill was transplanted 1-2 cm deep into the soil that is muddy but not flooded at a spacing of 25 x 25 cm on the same day of transplanting.

Rice crop was grown with a uniform application of recommended NPK (120 kg N, 60 kg P and 25 kg K/ha) in conventionally established plots while in SRI established crop, 25% of the recommended dose of NPK was supplied through well decomposed FYM on oven dried N content (0.62%) basis and remaining amount of NPK was supplied through inorganic sources of nutrients from urea, DAP and MOP, respectively. One third amount of N and full dose of P and K were applied as basal dose at the time of transplanting. Remaining N was top dressed in two equal splits at 30 days intervals. Irrigation was applied at regular intervals in conventional method of rice establishment to keep the water standing in the plots throughout the crop season with intermittent drainage whereas in case of SRI, plots were irrigated so as to keep the soil moist and no water was allowed to stand in the plot until the crop entered the reproductive stage. After panicle initiation, a thin layer of water (1-2 cm) was maintained until 10-15 days before the crop was harvested. All the herbicides were applied with the help of knapsack sprayer 20 days after transplanting as per treatment.

Data on weeds were subjected to square root transformations. All the data were analyzed by using ANOVA, and the least significant difference (LSD) value at 5% level of significance were calculated and used to test significant differences between treatment means.

RESULTS AND DISCUSSION

Effect on weeds

The major weeds species recorded in weedy plots were *Echinochloa colona* (38%)*, Echinochloa crusgali* (28%)*, Caesulia axillaris (*10.5%*), Eclipta alba* (6.2%)*, Cyperus* spp *(*17.5%) *viz., C .iria, C. difformis, C. rotundus* and others (2%) (Table 1). Among the weed management practices, mechanical hoeing using conoweeder (twice at 15 days interval) reduced the total weed population and weed dry weight significantly at all the crop growth stages compared to that in weedy check plots and other herbicide treatments in comparison, but was at par with fenoxaprop-p-ethyl (at 0.06 kg/ha, 20 DAT) *fb* 1 HW at 30 DAT, followed by metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha, 20 DAT *fb* 1 HW at 30 DAT, fenoxaprop-p-ethyl (at 0.06 kg/ha, 20 DAT) and metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha, 20 DAT). However, metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha) was found to be more effective against broad leaved weeds and very little to sedges, thus failed to control major grassy weeds during the experimentation while fenoxaprop-p-ethyl (0.06 kg/ha) effectively controlled grassy weeds and sedges. These results were in conformity with those observed by Singh *et al.* (2003). Among the establishment techniques, non-significant results were reported regarding weed population and weed dry weight during critical growth stages, though weed population and weed dry matter were numerically lower in conventionally sown plots than SRI plots. This might have been happened because of the shading effect of closely spaced paddy plants in conventional method which have resulted in comparatively lower weed population. Moreover, the experimental site represented the area where previously no rice crop was taken from last seven to eight seasons. This might have resulted in statistically similar weed dynamics in rice both in SRI and conventional methods of establishment.

Table 1. Weed density, dry matter and weed control efficiency as influenced by various weed management and establishment techniques of rice crop

Treatments	Doses (kg/ha)	Weed density (no./m^2)				Weed dry matter (g/m^2)				Weed control efficiency (%)			
		60 DAT		At harvest		60 DAT		At harvest		60 DAT		At harvest	
		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Weed management methods													
Weedy check	--	11.8 (137.8)	11.2 (124.5)	7.4 (54.6)	7.2 (51.6)	14.0 (195.22)	13.4 (177.7)	20.31 (412.0)	17.3 (298.8)	--	--	--	--
Weed free	--	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.71 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	100.0	100.0	100.0	100.0
Metsulfuron methyl *fb* chlorimuron ethyl	0.004 kg/ha (20 DAT)	8.2 (66.7)	7.4 (54.3)	6.5 (41.8)	6.0 (35.5)	5.28 (27.37)	5.2 (27.0)	6.7 (44.8)	6.2 (37.6)	86.0	91.2	89.9	92.2
Metsulfuron methyl *fb* chlorimuron ethyl *fb* I HW	0.004 kg/ha (20 DAT)	7.4 (53.5)	6.9 (47.5)	6.1 (36.7)	5.8 (33.5)	5.10 (25.51)	5.0 (24.6)	6.5 (41.1)	5.8 (33.3)	88.2	92.6	91.2	93.0
Fenoxaprop-p-ethyl	0.06 kg/ha (20 DAT)	7.5 (55.0)	7.0 (48.4)	6.2 (37.6)	5.9 (33.8)	4.9 (23.51)	4.8 (22.5)	6.0 (35.6)	5.9 (34.5)	87.2	92.6	90.2	93.1
Fenoxaprop-p-ethyl *fb* I HW	0.06 kg/ha (20 DAT)	6.2 (38.2)	5.70 (32.0)	4.9 (23.9)	4.7 (21.3)	3.97 (15.26)	3.3 (10.5)	4.4 (19.0)	4.2 (17.2)	92.4	94.3	95.5	94.4
Mechanical hoeing using conoweeder (at 15 and 30 DAT)	--	6.0 (35.5)	5.3 (27.6)	4.7 (26.0)	4.5 (20.0)	3.65 (12.82)	3.3 (10.4)	4.4 (18.5)	4.2 (17.1)	93.7	94.3	95.6	94.4
LSD (P=0.05)		0.4	0.3	0.4	0.4	0.62	0.3	0.6	0.3	-	-	-	-
Rice establishment methods													
Conventional	--	6.7 (44.4)	6.2 (37.4)	5.1 (25.5)	4.9 (23.5)	5.29 (23.48)	5.1 (25.2)	6.9 (47.2)	6.3 (39.6)	76.1	78.7	79.5	78.0
System of rice intensification (SRI)	--	7.0 (48.5)	6.6 (42.5)	5.4 (29.0)	5.1 (25.8)	5.53 (30.08)	5.2 (26.7)	7.2 (51.1)	6.4 (40.7)	73.1	76.2	74.4	77.8
LSD(P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	-	-	-	-

Figures in the parenthesis are original values; DAT - Days after trasplanting

Likewise, maximum weed control efficiency (95.6%) among the weed management practices was observed in treatment where mechanical hoeing using cono weeder twice was practiced and which was followed by fenoxaprop-p-ethyl (at 0.06 kg/ha, 20 DAT) *fb* 1 HW at 30 DAT (95.5%), metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha, 20 DAT *fb* 1 HW at 30 DAT (91.2%), fenoxaprop-p-ethyl (at 0.06 kg/ha, 20 DAT (90.2%) and metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg /ha, 20 DAT (89.2%). This might be attributed to the control of all categories of weeds *viz.,* grasses, sedges and broad leaved weeds with the application of these herbicides which reduced their dry weight than other treatments in comparison during both the crop seasons. However, fenoxaprop-p-ethyl (at 0.06 kg/ha) was found to be more effective than metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha) in controlling the grassy weeds and sedges, but metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha) failed to control major grassy weeds, the infestation of which was more in the experimental field.

Effect on yield attributes and yield

All the weed management and establishment techniques improved all the yield attributes of rice as compared to those observed in control plots (Table 2). Mechanical hoeing using cono weeder twice (10 and 20 DAT) recorded higher values of yield attributing characters *viz.* panicle length (cm), panicle weight (g), number of grains/ panicle, grain weight/ panicle (g) which were reported to be at par with those of fenoxaprop-p-ethyl (at 0.06 kg/ha) *fb* 1 H.W at 30 DAT, metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha) *fb* 1 H.W at 30 DAT and fenoxaprop-p-ethyl (at 0.06 kg/ha), but significantly superior to metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha). However, effective tillers were slightly less in treatment where mechanical hoeing was done using conoweeder twice (15 and 30 DAT) as compared to fenoxaprop-p-ethyl (at 0.06 kg/ha) due to presence of more percentage of unfertile tillers, but both were statistically at par with each other. Likewise, 1000 grain weight was maximum in mechanical hoeing treatment followed by fenoxaprop–p-ethyl (at 0.06 kg/ha) *fb* 1 HW at 30 DAT, metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha) *fb* 1HW at 30 DAT and fenoxa-prop-p-ethyl (0.06 kg/ha) than weedy check and other treatments (Table 2). This increase in yield attributing characters might be due to lower weed population and dry weight of weeds which may have enhanced N, P and K uptake besides efficient use of moisture, space and light. These results corroborated with the findings of Singh *et al.* (2006).

With regard to the establishment methods, the conventional method recorded slightly higher number of effective tillers/m^2 which was at par with SRI method. The possible reason for this is that at closer spacing, the production of tillers might be more per unit area having more plants/ha. Similar results were reported by Dixit *et al.* (2007) and Latif *et al.* (2004). However, longer and heavier panicles along with more number of grains were recorded with SRI technique which was statistically at par with conventional technique. This might be due to transplanting of young, single and widely spaced seedling which might have resulted in better availability of nutrients, light and space during growth stages. Similar results have been reported by Thakur (2005) and Rahman and Roy (2006). No significant difference was observed in the test weight of paddy obtained by SRI technique or conventional practice. This is in conformity with the results of Latif *et al*. (2004).

Grain yield is a resultant of yield attributes and therefore, maximum expression of yield attributes *viz.*,effective tillers, panicle length, grains/panicle and 1000 grain weight due to reduced crop weed competition in weed free plots resulted in higher grain yield by 34.04 and 33.71% than that observed in weedy check plots during two crop seasons, respectively.

In general, weed management practices and establishment techniques significantly increased the grain and straw yields of rice as compared to that achieved in control plots. Among the weed management treatments, highest grain and straw yield of rice was recorded in the treatment using mechanical hoeing which was statistically at par with fenoxaprop-p-ethyl (at 0.06 kg/ha) *fb* 1 HW at 30 DAT, metsulfuron methyl *fb* chlorimuron ethyl (at 0.004 kg/ha) *fb* 1 HW at 30 DAT and fenoxaprop-p-ethyl (at 0.06 kg/ha) which were significantly superior to control and other treatments. The possible reason for the better performance of these treatments in terms of grain and straw yield could be attributed to better expression of their yield attributes due to better management practices and reduction in crop- weed competition, resulting in significant reduction in dry weight and weed population. The results were in close conformity to those given by Singh *et al.* (2003). Lowest grain yield of rice was recorded in treatment where only metsulfuron methyl *fb* chlorimuron ethyl) was applied. This might be due to inefficiency to control the heavily infested grassy weeds.

However, under establishment methods, statistically non-significant results were observed in the grain and straw yields of both the conventional and SRI methods of establishment, but slight higher values were recorded under conventional method.

The highest and lowest harvest index values were recorded in weed free and weedy check plots, respectively

Table 2. Effect of weed management and rice establishment techniques on yield attributes of rice

Treatments	Doses (kg/ha)	Effective tillers (no./m^2)		Panicle length (cm)		Panicle weight (g)		No. of grains/ panicle		Grain weight/ panicle		1000 grain weight (g)	
		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Weed management methods													
Weedy check	--	180.2	194.3	20.4	20.5	1.7	1.8	76.0	77.2	1.5	1.6	21.3	21.4
Weed free	--	238.1	240.3	23.8	23.9	2.9	2.9	96.9	97.8	2.2	2.2	23.4	23.8
Metsulfuron methyl *fb* chlorimuron ethyl	0.004 kg/ha (20 DAT)	211.4	215.8	22.4	22.5	2.2	2.3	83.4	84.4	1.6	1.7	21.5	22'0
Metsulfuron methyl *fb* chlorimuron ethyl *fb* 1 H.W.	0.004 kg/ha (20 DAT)	223.4	225.9	22.7	23.0	2.4	2.5	87.5	88.7	1.8	1.9	22.3	22.7
Fenoxaprop-p-ethyl	0.06 kg/ha (20 DAT)	218.0	222.4	22.5	22.7	2.2	2.3	86.8	87.4	1.8	1.9	22.4	22.6
Fenoxaprop-p-ethyl *fb* I H.W	0.06 kg/ha (20 DAT)	228.6	230.2	22.9	23.0	2.5	2.6	89.2	91.3	1.9	2.0	22.5	22.7
Mechanical hoeing using conoweeder (at 15 and 30 DAT)	--	224.7	228.7	23.3	23.4	2.7	2.8	91.6	93.2	2.0	2.0	22.6	22.9
LSD (P=0.05)		10.7	8.3	0.9	0.7	0.4	0.5	4.9	5.9	0.2	0.2	0.7	0.6
Rice establishment methods													
Conventional	--	218.2	223.9	22.4	22.6	2.4	2.4	86.5	88.3	1.8	1.9	22.4	22.7
SRI	--	217.4	221.1	22.7	22.8	2.4	2.5	88.2	88.8	1.8	1.9	22.2	22.5
LSD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SRI - System of rice intensification; NS - Non significant; DAT - Days after transplanting; HW - Hand weeding

Table 3. Effect of weed management and rice establishment techniques on grain yield, straw yield and harvest index of rice

Treatments	Doses (kg/ha)	Grain yield (kg/ha)		Straw yield (kg/ha)		Harvest index (%)		Weed index (%)	
		2006	2007	2006	2007	2006	2007	2006	2007
Weed management methods									
Weedy check	--	3075	3145	4465	4626	40.78	40.42	34.04	33.71
Weed free	--	4662	4745	5819	6076	44.48	43.84	0.00	0.00
Metsulfuron methyl *fb* chlorimuron ethyl	0.004 kg/ha (20 DAT)	3700	3818	5066	5040	42.19	43.10	20.63	19.53
Metsulfuron methyl *fb* chlorimuron ethyl *fb* 1HW	0.004 kg/ha (20 DAT)	4054	4166	5143	5378	44.36	43.65	13.04	12.20
Fenoxaprop-p-ethyl	0.06 kg /ha (20 DAT)	3983	4087	5083	5342	43.43	43.34	14.56	13.87
Fenoxaprop-p-ethyl f *fb* 1HW	0.06 kg /ha (20 DAT)	4150	4268	5248	5583	44.15	43.32	10.98	10.05
Mechanical hoeing using conoweeder (at 15 and 30 DAT)	--	4256	4393	5381	5677	44.16	43.62	8.70	6.79
LSD (P = 0.05)		345	315	299	336	NS	NS	--	--
Rice establishment methods									
Conventional	--	3992	4109	5168	5336	43.58	43.24	14.37	13.40
SRI	--	3974	4068	5176	5440	43.43	43.03	14.75	14.26
LSD (P = 0.05)		NS	NS	NS	NS	NS	NS	--	--

SRI - System of rice intensification; NS - Non significant; DAT - Days after transplanting; HW - Hand weeding

during both the crop seasons (Table 3). However, under weed management practices, no significant difference was recorded among the different herbicide treatments. This may be attributed to significant control of mixed weed flora due to application of these herbicides which reduced the weed dry matter production by weeds, thereby shifting the competition in favor of rice crop, thus increasing photosynthesis and better translocation of photosynthates to the sink during reproductive phase. Likewise, establishment techniques did not bring about any significant changes in harvest index of rice.

The lowest weed index was recorded in treatment where mechanical hoeing was done and in fenoxaprop-p-ethyl *fb* 1 HW treatment. The lower weed index values might be due to lower weed population and weed dry weight as a result of maximum weed control efficiency (Table 1). The interaction effects were however found to be non-significant between weed management and establishment methods.

Hence, establishment techniques and weed management methods in rice during both the years showed superiority of the treatment where mechanical hoeing with conoweeder was used which was statistically at par with fenoxaprop-p-ethyl (Puma super at 0.06/ha) *fb* 1 HW, metasulfuron methyl *fb* chlorimuron ethyl (Almix at 0.04/ha) and *fb* 1 HW and fenoxaprop-p-ethyl.

REFERENCES

Dixit AK, Sharma BC, Bali AS and Bazaya BR. 2007. Refinement of basmati rice establishment techniques for higher productivity and profitability and its impact on succeeding conventionally and zero tilled sown wheat crop. In*: SRI India 2007.* Second National Symposium on System of Rice Intensification (SRI) in India-Progress and Prospects held at Agartala, Tripura, India during 3-5 October 2007.

Gautam KC and Mishra JS. 1995. Problems, prospects and new approaches in weed management. *Pesticides information* **21**: 7-19.

Latif MA, Ali MY, Islam MR and Rashid MH. 2004. Compilation Report on Extension of the System of rice Intensification (SRI) through verification. *http:// ciifad. Cornel edu/ sri/ wrrc/ bd wrre.*

Rahman M and Roy IB. 2006. Effect of System of Rice Intensification (SRI) on rice yield in Bangladesh, Boro season. http://ciifad. Cornell./ edu/ sri/ Bangladesh/ bastion aid 0506 .

Singh VP, Singh G, Singh SP, Kumar A, Sharma G, Singh MK, Mortimer M and Johnson DE. 2006. Effect of weed management and crop establishment methods on weed dynamics and grain yield of rice. *Indian Journal of Weed Science* **38** (1&2): 16-19

Singh Samar, Singh H, Narwal S and Malik RA. 2003. Performance of herbicides in transplanted rice. *Indian Journal of Weed Science* **35** (1&2): 114-116.

Purushamam S. 1996. Competitive ability of weed flora in low land rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **66**: 70-72.

Thakur AK. 2005. System of Rice Intensification a new hope to boost rice production in canal command area. In *: National level training course on water management for sustainable agricultural production in canal commands* 19-25, Dec. *2005 (*Eds.) Singh Ravinder, Choudhary SK, Kandu DK. and Kar G.) organized by Water Technology Centre for Eastern Region 9ICAR), Bhubneshwar, Orissa : 82-84.

Uphoff N. 2005. Possible explanations for the Productivity gains achieved with System of Rice Intensification (SRI). In: *Transitions in Agriculture for enhancing water productivity.* Proceedings of an International Symposium held in Killikulam, Tamil Nadu, India during 23 -25, September 2005.