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Yield loss assessment of rice (O*ryza Sativa* L.) due to different biotic stresses under system of rice intensification (SRI)

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Abstract
The field experiment was conducted during 2015-16 at Viswavidyalaya farm on summer rice (*Oryza sativa* L. cv. IET 4786) following system intensification methodology to study the effects of three major pests (weed, insect and disease) on biological productivity. There were two treatments, unprotected and protected which were replicated six times following pair plot technique design. The invading weed, insect and disease pests in the experimental plots were identified. Weed pest caused maximum loss in seed yield 37.02% followed by insect pest 27.9% and disease pest 15.6%. SRI productivity increase may be attributed to improvement in growth and yield parameters resulting from management of pests in the respective critical infestation period. Ecosafe integrated management of all these three major pests during the critical crop pest competition period effectively below the ETL minimized losses to sustain paddy productivity at desired levels.

Keywords: Summer SRI, Dominant pest complex, Yield loss

1. Introduction
Rice is the world's most important staple food - grown in over 100 countries, consumed regularly by over two billion people and the primary source of protein for millions [1]. India is the leading rice (*Oryza saiva* L.) producing country in terms of area and is the second largest producer next to China [2]. Rice plays an important role in food as well as livelihood security for almost every household, more so in West Bengal delta. To feed this estimated 1.6 billion population of India by 2050 calls for stepping up the current production of 106 mt of milled rice to 140 mt [3]. System of intensification is a methodology adopted in various ecosystems and deal with the sustainable best management practices of what farmers have within their available resources which offers the best alternative to increase the productivity of crops with minimum cost [4]. Among the major yield limiting factors pests are said to be an important one. Pest causes 33% production loss in India, the major pest weed causes 12.5 per cent whereas insect 9.5 per cent and disease 6.5 per cent besides other pests 4.5 per cent [5]. Therefore, minimizing the pest losses can be the most important approach to increased productivity. Dhaliwal and Arora [6] reported that different pests cause 25 per cent loss in rice, 5-10 per cent in wheat, 30 per cent in pulses, 35 per cent in oilseeds, 20 per cent in sugarcane and 50 per cent in cotton. Crop protection has been developed for the prevention and control of crop losses due to pests in the field (pre-harvest losses) and during storage (post-harvest losses). Database of loss estimates related to crops and pests are important prerequisites for economic management of pests and for evaluating the efficacy of the present crop protection practices. Based on these data, strategies for the use of limited resources may be developed in order to optimize productivity [7, 8]. Therefore, to improve pest management and increase the sustainability of agriculture, it is necessary to take an integrated system approach of management. Considering these facts, the present experiment has been carried out to estimate the yield losses of summer SRI due to the three major pests (weed, insect and disease).

2. Material and Methods
2.1 Experimental site
The present field experiment was conducted in humid sub-tropics of West Bengal at the Instructional Farm, Jaguli of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, India

during summer season of 2015-16. The experimental site was situated at 22°56' N latitude, 88°32' E longitude and at an altitude of 9.75 m above the mean sea level (MSL). Soil at the experimental site was sandy clay loam (sand 47.21%, silt 20.23%, and clay 32.57%) with medium water holding capacity, the pH of the experimental soil was 6.83 with organic carbon of 0.61%, available N of 234.50 kg ha^{-1}, available P of 29.12 ka ha^{-1} and available K of 150.32 kg ha^{-1}.

2.2 Experimental design

The experiment was divided into three separate parts (weed, insect and disease pests), two treatments for each pest *viz.* untreated control (unprotected) and full treated (protected) were replicated six times following pair plot technique in a plot size of 5 m x 3 m.

2.3 Crop management

Rice variety IET 4786 after treating with salt water @ 160 g lit^{-1} of water followed by *Trichoderma viride* @ 4 g kg^{-1} and Azotobactor @ 250 g kg^{-1} was broadcasted in nursery. The recommended fertilizer doses $N:P_2O_5:K_2O$ @ 100:50:50 kg ha^{-1} were used in main field along with 5 t ha^{-1} neem cake (excepting in untreated insect control plot). 20 days old seedlings were transplanted with 20 cm (P-P) and 25 cm (R-R) spacing during 2nd week of February and 118 days crop was harvested. Irrigation was provided only to maintain the field in moist condition excepting three important rice physiological stages i.e., active tillering, panicle initiation and flowering stage. Weed pest control measures in the plots was done by hand pulling of germinated weed flora at each week interval. Insect pest control measure was adopted by applying two insecticides, Chlorantraniliprole 0.4% GR (Ferterra) @ 4 kg $acre^{-1}$ at 25 and 50 DAT and a ready-mix insecticide Profex super (Profenofos 40% + Cypermethrin 4% EC) @ 1 ml lit^{-1} of water at 35 DAT and 65 DAT while for disease pest the mixed fungicide Combi plus (Carbendazim 12% + Mancozeb 63% WP) @ 1.5 g lit^{-1} of water was used when the symptoms appeared in the field at 30 and 55 DAT.

2.4 Measurements and observations

2.4.1 Observation on weed pests

The density and biomass of different species of grasses, sedges and broad leaf weeds were recorded at 30, 50 and 70 DAT. The weed flora collected from each plot using quadrate were oven dried at 60 ± 2°C till a constant weight was obtained. The dry weight was expressed in g m^{-2}. Weed Index and Weed pest management index was calculated and expressed as suggested by Gill and Vijaya kumar [9] and Mishra and Misra [10] respectively.

Weed index (%) = (X-Y)/X × 100

Where, X = Grain yield from weed free (hand weeding) treatment, Y = Grain yield from treatment for which weed index is to be worked out.

Weed Pest Management Index (WPMI): PYWC÷PCWP

Where, PYWC = Per cent yield over unprotected plot, PCWP = Per cent control of the weed pest

2.4.2 Observation on insect pests

Five plants were selected at random from each plot of the insect pest experimental part and tagged. The observation for mean insect population plant-1 was counted in the early morning hours (by 7:00 a.m.) at 30, 50 and 70 DAT. Damages caused by insects were recorded by counting insect affected leaf, tiller and panicle. Insect Pest Management Index was calculated and expressed as suggested by Ghosh *et al.* [11].

Insect Pest Management Index (IPMI): IYIC÷ PCIP

Where, IYIC = Per cent yield over insect check plot, PCIP = Per cent control of the insect pest

2.4.3 Observation on disease pests

The severity of the diseases was recorded at 30, 50, 70 and 90 DAT on five randomly selected plants of each plot using the following rating scales. After scoring for different diseases PDI were calculated for each of the diseases separately. Blast disease of rice was scored based on 1-9 scale by following international rice research institute recommended grading scale [12]. Scoring of brown spot of rice was done by using the 0-9 rating scale by following international rice research institute recommended grading scale [12]. Recorded infection scores were then used in calculation of Percent Disease Index (PDI) as suggested by McKinny [13].

$$PDI = \frac{\text{Sum of individual disease rating}}{\text{Number of samples} \times \text{Maximum disease grade}} \times 100$$

2.4.4 Observation on crop growth and yield attributes and yield of rice

The LAI and Leaf chlorophyll was measured at 20, 40, 60 and 80 DAT randomly by using LAI meter (Model YMJ-B, Sr. No. 0811-14) and Chlorophyll meter of SPAD, Minolta (Model 502 of Minolta, Japan) respectively. Yield and yield components of rice along with harvest index were also estimated.

Pest Management Index (PMI), Agronomic Management Index (AMI) and Integrated Pest Management Index (IPMI) was calculated and expressed as suggested by Mishra and Misra, [10].

PMI = PYC÷PCP

Where, PYC = Per cent yield over control, PCP = Per cent control of the pest

AMI = (PY-PCWP)/PCP

Where, PY = Per cent yield, PCWP = Per cent control of the weed pest, PCP = Per cent control of the total pest

IPMI = (PMI+AMI)/2

Where, PMI = Pest Management Index and AMI = Agronomic Management Index

2.5 Statistical Analysis

The statistical analysis of the recorded data was done by t-Test: two-sample assuming equal variance which is also known as Fisher t-Test and the pest loss assessment was performed according to the suggestions of Leclerg [14].

3. Results and Discussion

3.1 Weed density and biomass

The result related to weed density and biomass (Table 1) showed that gradual increasing trend of the density and biomass of the weed flora from 30 to 70 DAT and the trend declined at the later stage of crop growth. In transplanted summer rice, the weed density and biomass is normally higher than that of the *kharif* rice. Moreover, as the crop was grown following SRI methodology, the more weed competition was observed as usually because of favorable low moisture status and suitable temperature under field condition. The higher density and biomass of the rice associated weed *Echinochloa formosensis* and others like *Leersia hexandra, Paspalum vaginatum, Cyperus difformis, Fimbristylis dichotoma, Ammania baccifera and Ludwigia octovalvis* were higher over the semi aquatic weeds like *Monochoria hastaefolia and Marsilea quadrifolia* due to use of alternate wetting and drying situation in the summer rice field.

3.2 Percent Disease Index (PDI) of the observed diseases in the disease pest experimental field

Results revealed that differences in PDI values, in unprotected plots over the protected ones, increased with both blast and brown spot diseases upto crop maturity. At 50, 70 and 90 DAT, significant variation was observed in both these two important rice diseases while calculating PDI between protected and unprotected plots. PDI was recorded highest at 90 DAT (39.89% in blast and 24.89% in brown spot) from the disease pest unprotected plots. The corresponding figures in the protected plots were 19.73% and 12.17% respectively (Table 2). Similar findings were also observed by Sharma *et al.* [15] and Hossain and Kulkarni [16]. The probable reason is the initial protective measure like seed treatment and later curative measure by applying premix molecule Combi plus (Carbendazim 12% + Mancozeb 63% WP) by two consecutive spray at the critical disease infestation period in the protected plots could able to reduce the disease infestation in SRI in comparison to the unprotected plots, where no such disease control measures were adopted. As a result, infestation of brown spot and blast disease of rice was slowed down gradually and the severity of these diseases showed below the ETL in the protected plots of disease pest experimental part.

3.3 Incidence of insects and their damage in the insect pest experimental field

Yellow stem borer recorded highest egg mass population (0.40 egg mass plant^{-1}) at 50 DAT from the unprotected plots (Table 3). Other observed insects like leaf folder (*Cnaphalocrocis medinalis*), gundhi bug (*Leptocorisa oratorius*) and rice skipper (*Pelopidas mathias*) also caused considerable damage. Protected plots of insect pest experimental part recorded 31.93 and 51.89% less dead heart attack during 30 and 50 DAT respectively and 57.4% less white head attack at 70 DAT from the unprotected plots. The findings were in line with the findings of Prasad *et al.* [17], Kakde *et al.* [18] and IRRI [19]. Lower insect population and damage were found from the protected plots over the unprotected plots, as chlorantraniliprole 0.4% GR and Profenofos 40% + Cypermethrin 4% E.C was applied to combat wide range of insect pest of rice when their population attained at ETL under field condition. Chlorantraniliprole 0.4% GR is a new generation di-amide molecule having novel target site (Ryanodine receptor) and acts as an insect growth regulator, which effectively managed yellow stem borer, leaf folder and other allied lepidopterans infesting rice [20]. Another premix molecule Profex super (Profenofos 40% + Cypermethrin 4% E.C) was applied by two consecutive spray operation in order to mitigate chewing as well as sucking pests of rice through contact and stomach action. Furthermore, use of balance nutrition in rice field using SRI methodology made the rice plants more competitive to save attack against these insects [21].

3.4 Effects of weed, insect and disease pests on growth and yield attributes of Summer SRI

Significant differences were observed on major growth (Table 4) and yield attributes (Table 5) between the protected and unprotected plots in weed pest experimental part. As the rice plants in protected plots were kept weed free throughout the crop growing period and had better utilization of available resources like, nutrients, space and water. More competition from weed flora in the critical phase of crop–weed completion decreases the growth and yield attributes in the unprotected plots. This finding is in agreement with that of Subramanian *et al.* [22], who reported that proper weed-management practices adopted in wet seeded rice improved the growth parameters and yield by eliminating weed competition. PDI data (Table 2) showed that the disease severity was also more in the unprotected plots than the protected plots during the time of investigation. Severe spotting on the leaves reduced the surface area for active photosynthesis which affected growth, biomass and yield attributes of rice in the unprotected plots. Such differences also characterized respective values in the insect affected plots. This differences was mainly due to protected plots were controlled by ecosafe measures while in the unprotected plots no insect control measures was adopted [23]. In the unprotected plots, chewing pests like yellow stem borer bore inside the panicle through the lower part covered with the leaf sheath resulting dead heart during vegetative phase and white head at reproductive phase culminates huge dry matter loss of rice plant [18]. Likewise, leaf folder scrap and feed the green matter of the leaves and make brownish tunnel on leaf surface, sap suckers like green leaf hopper and brown plant hoppers suck the cell sap from different plant parts resulting loss of LAI and leaf chlorophyll.

3.5 Effects of weed, insect and disease pests on grain and straw yield and harvest index of Summer SRI

Maximum grain yield was obtained from the protected plots of weed pests (5.21 t ha^{-1}), followed by the insect (5.15 t ha^{-1}) and disease pests (5.10 t ha^{-1}). The corresponding figures in unprotected plots were 3.29, 3.73 and 4.29 t ha^{-1} (Table 5). Significant differences were observed in all the three major pests taken under observation. Protected plots under weed pest recorded an extra yield advantage of 1.92 t ha^{-1} from their unprotected plots. More yields under the protected plots may be associated with lesser crop weed competition in the critical crop weed competition period along with higher dry matter accumulation, LAI and greater number of effective panicles m^{-2} and filled grain %. These observations are fully supported by Rajkhowa *et al.* [24] where it has been documented that proper weed-control methods during the critical crop growth stages, significantly improved the yield attributes in rice might be due to decreased weed–crop competitions and thereby providing better crop-growing environment and nutrition to the crop. Similar observations were also recorded in case of other two important pests, *i.e.* 1.45 t ha^{-1} (insect pest) and 0.81 t ha^{-1} (disease pest) more grain yield of rice were obtained in protected plots compared to their unprotected plots only because of adapting proper pest management practices in appropriate insect and disease infestation period which was in conformity with the results of Karmakar *et al.* [25]. The protected plots of weed, insect and disease pest recorded 1.43 t ha^{-1}, 1.13 t ha^{-1} and 0.74 t ha^{-1} more straw yield from their respective unprotected plots. Significant variation had been observed between the treatments of weed and disease pest experimental part on harvest index of rice (Table 5).

3.6 Yield loss due to weed, insect and disease pests

The biological yield data (Table 5) states that the losses due to weed pests in grain and straw were maximum 37.02% and 23.12% in comparison to insect pest 27.90% and 18.23% and disease pests 15.60 and 12.35%. The results were in accordance with the findings of Saha [2], Barnwal *et al.* [26], Hossain and Kulkarni [16] and Dhaliwal *et al.* [27]. The result therefore showed that weed is the major pest in comparison to other two dominant pests, i.e. insect and disease.

3.7 Management index
The various management indices data (Table 6) showed that there is a significant positive interaction of the management practices of different pests in this experiment. The positive 37.01 value of weed index indicates that in protected plots due to managing weeds more particularly in critical weed pest infestation period in SRI, weed competition was below the ETL and thus 37.01% yield loss could be recovered. The similar advantages were recorded through WPMI value showing 59% more efficiency while IPMI and DPMI values were 39 and 19% lesser competition, respectively. The average PMI value indicates 37% more contribution in grain yield of SRI by minimizing the losses in protected plots through reducing the competition for the available resources offered by these three major pests in the experimental plots. Similar findings were also observed by Ghosh [28] while working on yield loss due to pests' in rapeseed at Gangetic alluviam. Results therefore, indicate that timely ecosafe management of these three important pests is more important to reduce their competition for available resources in their critical crop infestation period [28] and thereby increase the grain yield by increasing the growth and yield attributes of summer SRI.

Table 6: Management index as influenced by different pests

Weed index (WI)	**:**	**37.01**
Weed pest management Index (WPMI)	:	1.59
Insect pest management Index (IPMI)	:	1.39
Disease pest management Index (DPMI)	:	1.19
Agronomic management Index (AMI)	:	0.81
Pest management index(PMI)	:	1.37
Integrated pest mgt Index (INPMI)	:	1.09

3.8 Correlation coefficients between the severity of three dominant pests (Weed, insect and disease) and major crop growth, yield attributes
The correlation study with the three major pests' weed (biomass), insect (population) and disease (PDI) with major growth and yield attributes and the biological yield (Table 7) revealed that the weed biomass, insect population and disease PDI had registered a strong significant negative correlation with major crop growth and yield attributes of summer SRI because of the reason that there was a tough competition of the resources in the respective critical pest infestation period [28]. While all the measured crop growth and yield attributes were positively correlated with grain and straw yield of rice. The strongest positive relationship of grain yield for growth attributes recorded with dry matter accumulation (r =0.920). While the same for yield attributes was number of panicle m^{-2} that recorded the strongest correlation (r =0.803**) followed by filled grain percentage (r= 0.738). Samonte *et al.* [29] in his research articles also mentioned that rice grain yield is the function of number of filled grains per panicle while Iftekharuddaula *et al.* [30] reported about number of effective tillers m^{-2}. According to Ghosh [28], proper ecosafe management in time of critical infestation of pests, allows the pests populations bellow the ETL which support the crop to grow in an environment where pest competition was minimum.

Table 1: Density and biomass of weed pest in unprotected plots of weed pest experimental part of summer SRI

Weeds	**Density of weeds (m^{-2})**			**Dry weight of weeds (g m^{-2})**		
	30 DAT	**50 DAT**	**70 DAT**	**30 DAT**	**50 DAT**	**70 DAT**
Grassy weeds						
Echinochloa formosensis	6.33 (3.02)*	7.33 (2.79)	7.50 (2.83)	25.52 (5.55)	42.45 (7.02)	59.80 (8.23)
Leersia hexandra	2.83 (2.18)	3.00 (1.87)	3.16 (1.91)	5.52 (2.85)	10.07 (3.67)	15.16 (4.34)
Paspalum vaginatum	3.16 (1.91)	3.33 (1.96)	3.50 (2.00)	7.92 (3.31)	13.52 (4.18)	19.12 (4.87)
Other grasses	3.33 (1.96)	3.83 (2.08)	4.00 (2.12)	9.59 (3.60)	19.20 (4.88)	23.70 (4.37)
Sedge weeds						
Cyperus difformis	38.50 (6.25)	46.00 (6.82)	48.67 (7.01)	42.80 (4.34)	60.63 (8.28)	74.30 (9.11)
Fimbristylis dichotoma	3.83 (2.46)	4.00 (2.12)	4.16 (2.16)	6.42 (3.03)	9.24 (3.54)	11.15 (3.84)
Broadleaf weeds						
Alternanthera philoxeroides	5.33 (2.42)	5.50 (2.45)	5.83 (2.52)	7.99 (3.33)	12.82 (4.08)	16.15 (4.52)
Monochoria hastaefolia	1.00 (1.23)	1.16 (1.27)	1.16 (1.29)	1.88 (1.87)	2.54 (2.09)	4.88 (2.70)
Ammania baccifera	2.66 (1.78)	2.83 (1.83)	3.00 (1.87)	2.53 (2.09)	4.85 (2.70)	7.85 (3.30)
Ludwigia octovalvis	2.33 (1.68)	2.50 (1.73)	2.50 (1.73)	3.70 (2.42)	7.25 (3.19)	11.72 (3.92)
Other dicots	4.66 (2.27)	4.83 (2.31)	5.16 (2.37)	4.51 (2.62)	8.85 (3.47)	15.46 (4.43)

*Figures given in the parenthesis are the square root transformed values $(\sqrt{x + 0.5})$

Table 2: Percent Disease Index (PDI) of the observed diseases in disease pest experimental part of summer SRI

Treatments	**Percent disease index (PDI)**			
	30 DAT	**50 DAT**	**70 DAT**	**90 DAT**
Blast				
Protected	3.67	8.53	12.61	19.73
Unprotected	4.37	17.56	32.74	39.89
Fisher (*t*)	1.89^{NS}	9.51**	12.45**	38.73**
Brown spot				
Protected	1.76	5.86	8.33	12.17
Unprotected	1.93	11.19	18.52	24.89
Fisher (t)	0.34^{NS}	5.85**	8.68**	10.53**

**Significant at the 0.01 level. NS= Non Significant

Table 3: Population of dominant insect pests and their damage in insect pest experimental part of summer SRI

Types of insect pest		Insect population $plant^{-1}$ and damage			
		Treatments	**30 DAT**	**50 DAT**	**70 DAT**
Yellow stem borer	Egg mass	Protected	0.10 (1.05)	0.13 (1.04)	0.00
		Unprotected	0.36 (1.16)	0.40 (1.18)	0.00
		Fisher (*t*)	3.25**	4.00**	-
Yellow stem borer	Dead heart (%) or White head (%)	Protected	5.67 (13.52)	5.33 (13.25)	6.17 (14.35)
		Unprotected	8.33 (16.67)	11.08 (19.26)	14.50 (22.17)
		Fisher (*t*)	2.19^{NS}	3.94**	4.34**
Leaf folder	Folded leaf	Protected	0.13 (1.06)	0.17 (1.07)	0.00
		Unprotected	0.22 (1.10)	0.97 (1.39)	0.00
		Fisher (*t*)	1.27^{NS}	4.94**	-
Leaf folder	Larva	Protected	0.03 (1.02)	0.13 (1.06)	0.00
		Unprotected	0.11 (1.05)	0.40 (1.18)	0.00
		Fisher (*t*)	1.61^{NS}	3.16**	-
Rice skipper	Larva	Protected	0.00	0.83 (1.04)	0.00
		Unprotected	0.00	0.20 (1.10)	0.00
		Fisher (*t*)	-	2.91*	-
Gandhi bug	Nymph and adult	Protected	0.00	0.00	0.67 (1.29)
		Unprotected	0.00	0.00	1.10 (1.45)
		Fisher (*t*)	-	-	2.48*

**Significant at the 0.01 level. *Significant at the 0.05 level.

Figures given in the parenthesis are the square root transformed values $(\sqrt{x+1})$

Figures given in the parenthesis for per cent Dead heart or per cent White head are the angular transformed values

Table 4: Effects of weed, insect and disease pests on growth attributes of Summer SRI

Treatments	Chlorophyll content (%)			Leaf area Index			Dry matter accumulation		
	20 DAT	**40 DAT**	**60 DAT**	**20 DAT**	**40 DAT**	**60 DAT**	**30 DAT**	**50 DAT**	**70 DAT**
Weed pest experimental part									
Protected	36.3	40.9	46.13	1.91	3.46	4.57	202.25	340.14	602.79
Unprotected	34.1	38.9	41.61	1.81	2.50	3.63	179.26	308.39	558.15
Fisher (*t*)	1.86^{NS}	2.39*	2.87*	0.80^{NS}	2.27*	2.28*	3.05*	3.60*	5.23**
Loss (%)	6.21	4.87	9.80	5.56	27.74	20.56	11.37	9.33	7.40
Insect pest experimental part									
Protected	36.3	41.36	45.24	1.94	3.46	4.58	199.93	341.14	604.45
Unprotected	35.3	40.09	42.15	1.89	3.36	3.78	185.93	326.79	578.33
Fisher (*t*)	0.11^{NS}	1.06^{NS}	2.26*	3.37^{NS}	0.78^{NS}	2.88*	1.83^{NS}	1.99^{NS}	3.83*
Loss (%)	2.70	3.06	6.81	2.24	2.79	18.12	7.00	4.20	4.32
Disease pest experimental part									
Protected	36.3	41.8	46.8	1.94	3.48	4.61	204.52	341.90	604.12
Unprotected	36.1	34.2	43.1	1.88	3.37	4.55	190.34	331.97	585.54
Fisher (*t*)	0.10^{NS}	3.35**	2.96*	0.33^{NS}	0.51^{NS}	0.26^{NS}	1.79^{NS}	1.22^{NS}	2.48*
Loss (%)	0.40	18.14	7.84	2.93	3.02	1.12	6.93	2.91	3.07

**Significant at the 0.01 level. *Significant at the 0.05 level. NS- Not Significant

Table 5: Effects of weed, insect and disease pests on yield and yield components of summer SRI

Treatment	Number of effective panicles m^{-2}			Filled grains (%)			Test weight (g)		
	Weed	**Insect**	**Disease**	**Weed**	**Insect**	**Disease**	**Weed**	**Insect**	**Disease**
Protected	308	308	305	80.1	81.0	79.8	20.2	20.5	20.2
Unprotected	236	268	279	68.05	71.4	74.8	19.4	20.4	20.1
Fisher (*t*)	19.96**	8.16**	5.76**	10.62**	6.27**	3.84**	0.81^{NS}	0.08^{NS}	0.13^{NS}
Loss (%)	23.38	12.98	8.52	15.04	11.83	6.36	3.95	0.81	0.44
Treatment	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})			Harvest index (%)		
	Weed	Insect	Disease	Weed	Insect	Disease	Weed	Insect	Disease
Protected	5.21	5.18	5.10	6.16	6.20	6.02	45.90	45.51	45.87
Unprotected	3.29	3.73	4.29	4.73	5.07	5.28	41.15	42.39	44.95
Fisher (*t*)	10.47**	11.83**	6.94**	3.97**	5.31**	3.14**	3.28*	4.16**	0.90^{NS}
Loss (%)	37.02	27.90	15.60	23.12	18.23	12.35	10.36	6.86	2.04

**Significant at the 0.01 level. NS- Not Significant

Table 7: Correlation coefficients between the intensity of three dominant pests (weed, insect and disease) and major growth and yield attributes of summer SRI

Traits	Weed biomass (g m^{-2})	Insect population	Disease PDI	LAI	DMA	Number of panicle m^{-2}	Filled grains (%)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Weed biomass (g m^{-2})	1								
Insect population	-0.629*	1							
Disease PDI	-0.727*	-0.585*	1						
LAI	-0.720*	-0.813*	-0.764*	1					
DMA	-0.766*	-0.832*	-0.715*	0.744*	1				
Number of panicle m^{-2}	-0.585*	-0.716**	-0.719*	0.584	0.018	1			
Filled grains (%)	-0.725*	-0.798**	-0.726*	0.464	0.690	0.428	1		
Grain yield (t ha^{-1})	-0.964**	-0.821**	-0.787**	0.659*	0.920	0.803**	0.738**	1	
Straw yield (t ha^{-1})	-0.841**	-0.780**	-0.742**	0.714*	0.673*	0.866*	0.860*	0.673*	1

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

4. Conclusion
This comparative assessment of weed, insect and disease pests helped us to understand the extent of losses in seed yield of SRI under prevailing pest scenario is offered most by weeds (37.02%) followed by insects (27.9%) and then by diseases (15.6%) and how ecosafe management options respond to crop - pest competition. By minimizing the losses due to these major pests (weed, insect and disease) the paddy productivity could be increased to the desired level. Ecosafe integrated management of all these major pests during their critical crop pest competition period, so that the infestation could be brought below the ETL. The average PMI value indicates 37% more contribution in grain yield of SRI by minimizing the losses in the experimental plots. The findings of the experiment may also help farmers to strategize their crop protection plan accordingly in summer SRI in the light of individuals' resource affordability.

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