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Status of Insect Pests and Natural Enemies of Direct Seeded and Transplanted Rice

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Abstract

Studies were conducted on the status of insect-pests and natural enemies of direct seeded rice (DSR) in comparison with puddled transplanted rice (PTR) during rabi and kharif in 2013-14. The rice leaf folder and yellow stem required both the seasons. Maximum leaf folder Cnaphalocrocis medinalis (Guenee) (13.03%) damage and yellow stem borer damage (13.49%) of white ears was recorded during last week of October and second week of November in DSR under unprotected situation respectively. While sucking pests population mainly green leafhopper incidence was comparatively high in PTR (3.29 and 4.92/hill) also plant hoppers incidence (BPH and WBPH) (28.90 and 18.44 adults/hill) under unprotected situation during two seasons respectively. Population of predators at both the season remained high throughout the study period in PTR than the DSR except

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rove beetles (Paederus fuscipes Curt) whose population was more in DSR compared to PTR. The biochemical composition of rice plant from DSR and PTR was estimated during 30, 60 and 90 days old crop from both ecosystems. At 30 days old crop phenol and soluble protein content was more and it was negatively correlated with the incidence of panthoppers. Similarly, Total sugar content was higher in PTR (23.04 and 18.24mg/g) at 90 days old crop and it was positively correlated (r= 0.936** and r= 0.296**) with plant hoppers.

Keywords: Direct seeded rice, Puddled transplanted rice, Cnaphalocrocis medinalis, Scirpophaga incertulas, Nephottetix virescens, Nilaparvata lugens, Sogatella furcifera

Introduction

Rice (*Oryza sativa* L), the staple food of more than half of the population of the world, is an important target crop to provide food security and livelihoods for millions. In India, rice is grown mainly by transplanting the seedlings into puddled soil, which require significant amount of water and labour. However, in recent years both are scarce and expensive, making rice production less profitable coupled with excessive use of nitrogenous fertilizers and abuse of agrochemicals have further aggravated the pest menace in transplanted condition (Anon., 2010). All these factors demanded major shift from Puddled Transplanted Rice (PTR) Direct Seeded Rice (DSR) in irrigated and assured or high rainfall areas. Direct seeded rice technique is becoming popular nowadays because of its low-input demanding nature. This method has become inevitable for tail-end farmers who receive less amount of irrigation water. Among the major insect pests attacking rice are rice leaffolder, *Cnaphalocrocis medinalis* (Guenee), brown planthopper, *Nilaparvata lugens* (Stal), whitebacked planthopper, *Sogatella furcifera* (Horvath) and yellow stem borer, *Scirpophaga incertulas* (Walker). The loss due to yellow stem borer ranged from 3 to 65 percent (Muralidharan and Pasalu, 2005) and leaffolder reported to the extent of 5 to 39 percent (Shanmugam *et al.*, 2006). A change from transplanting to direct seeding may affect the status of various pests. The main factors that influence pest status are exposure of very young seedlings to pests, longer plant duration in the field and increasing plant density. This study describes possible changes in pest status and natural enemies in direct seeded rice fields. It is felt that a complex and rich web of general and specific insect pests and natural enemies of direct-seeded rice (DSR) ecosystem need to be studied.

Material and Methods

Field experiment was conducted during *rabi* 2012-13 at Mallat village of Raichur district and *kharif* 2013-14 at Agricultural Research Station, Gangavathi of Koppal district of UAS Raichur, Karnataka under protected and unprotected condition. Experiment laid out in Randomized Complete Block Design with five replications having four treatment combinations. The treatments consisted of protected DSR (T_1) and unprotected DSR (T_2) likewise, in transplanted situation under protected condition (T_3) and unprotected transplanted rice (T_4). The size of individual plot was 5 m × 4 m (20 m^2) in which the crop geometry for transplanting rice was maintained at 30 cm × 10 cm (row to row and hill to hill spacing) with three to four seeding per hill. In DSR plots, crop geometry was maintained at 22.5 cm × 10 cm (row to row and hill to hill) with single seedling per hill. All the agronomic practices followed in raising the crop was as per the recommended package of practice of UAS Raichur (2013).

Documentation of insect-pests and natural enemies

The observation on status of insect-pests and natural enemies in DSR and PTR crop was recorded at ten days interval.

Yellow stem borer incidence regarding dead hearts (prior to earhead formation) and white ears on 10 randomly selected hills in each quadrant. The per cent dead heart or white ears were calculated using following formula as suggested by Kaushik Chakraborty (2011).

$$\text{Per cent stem borer incidence} = \frac{\text{Number of dead heart/white ears}}{\text{Total number of plants/panicles}} \times 100$$

Leaf folder incidence was assessed by damaged leaves and total leaves from 10 randomly selected hills were observed in each quadrant. Per cent of leaf damage was calculated by using the following formula as advised by Muhammad Sagheeer *et al*. (2008).

$$\text{Per cent leaffolder incidence} = \frac{\text{Number of damaged leaves}}{\text{Total number of healthy leaves}} \times 100$$

The number of motile stages (nymphs and adults) of green leafhopper and plant hoppers (BPH and WBPH) from 10 randomly selected hills were counted by tapping and physical counting and expressed per hill.

Natural enemies were also recorded on same hills which were selected for recording the insect-pest population. The common predators *viz.,* spiders, mirid bugs and Coccinellids were counted on 10 hills in each plot and later averaged to per hill basis.

Statistical analysis

Data collected on various insect pests and natural enemies in the experiments were statistically analysed using randomized complete block design and t-test respectively. Square root transformation ($\sqrt{x}$ + 0.5) was followed for converting the population numbers.

Biochemical analysis of plants collected PTR and DSR

Biochemical and physiological analysis of direct seeded and transplanted rice was made by samples of rice crop collected separately from direct seeded rice and transplanted rice. Chemical compounds like free phenols, total sugars and soluble protein from the plant samples were estimated at different crop stages *viz.,* 30, 60 and 90 day after sowing by following the standard procedures. All the biochemical components were estimated from leaf sheath.

Estimation of total sugars

Total sugars present in plant samples was estimated by Nelson Somgy's method by using spectrophotometer (Nelson, 1994). Total sugars were calculated by using the following formula.

Procedure followed

Fresh leaves (5 g) of plants extract were homogenized in hot 80 per cent ethanol and 10 ml distilled water was added to dissolve the sugars. Reducing sugars were estimated by using DNSA reagent calorimetrically at 510 nm wavelength and calculated from graph plotted using glucose as a standard. Non-reducing sugars were estimated using anthrone reagent sample extractant were hydrolysed separately by keeping in boiling water bath for 3 hours with 2.5 N HCl (5 ml) and was neutralized with Na_2CO_3 after cooling it to room temperature. Volume was made up to 100 ml and Non-reducing sugars were estimated at 610 nm wavelength on UV-visible spectrophotometer and calculated from graph plotted using glucose as a standard. Total sugars were calculated by using the following formula.

Total sugar = Non reducing sugar - Reducing sugar

Expressed in mg/100 g sample

Estimation of free phenols

Free phenols present in plant samples was estimated by following Folin- Ciocalteau Reagent Method (FCR) by using spectrophotometer (Brays and Thocope, 1954). One ml of each alcohol extracts was taken in test tubes to which one ml of Folin-Ciocalteeau reagent and two ml of sodium carbonate solution (2 %) were added. The tubes were shaken well and heated in a hot water bath for exactly one minute and then cooled under running tap water. The blue colour developed was diluted to 25 ml with water and its absorbance was recorded at 650 nm in UV spectrophotometer. The amount of phenols present in sample was calculated from a standard curve prepared from Catechol.

Estimation of soluble protein

Soluble protein present in plant samples was estimated by following Lowrys method by using spectrophotometer (Lowry *et al.,* 1951). Plant samples (5 g) were homogenized in 2.5 ml of phosphate buffer (pH 7.0).The extract was centrifuged for 15 min at 4°C and the supernatant transferred to a tube containing a mixture of 20 ml acetone and 14 ml β-Mercaptoethanol for precipitation of protein. The sample tubes were stored at 0°C for 5 hr and then centrifuged at 10000 rpm for 20 min. The supernatant was discarded and the pellet dissolved in 2.5 ml sodium hydroxide solution. Aliquot of 0.2 ml from this sample was used to prepare the reaction mixture. The intensity of blue colour developed was recorded at 660 nm and protein concentration was measured using bovine serum albumin as standard.

Statistical analysis

Obtained on biochemical and physiological analysis was analysed by simple correlation method.

Results and Discussion

Rice leaffolder

Rice leaffolder incidence was observed maximum during crop growth period in direct seeded rice under unprotected situation in both the seasons. However, incidence was noticed during first fortnight of March (5.03%) and (4.18%) under unprotected condition of DSR and PTR during *rabi* (Table 1). These findings are in close conformity with the report of Mohan and Janarthanan (1985) who reported that peak activity of rice leaffolder was noticed between October and March. During *kharif* rice leaffolder damage was noticed from 50 days old crop in two rice growing methods. The per cent damage was more (13.01%) in unprotected DSR followed by unprotected PTR (9.48%). Maximum incidence was noticed when crop was between 70 and 80 days after sowing (Table 3). The results of present study are in agreement with the findings of Kuligod (2009) who observed the rice leaffolder damage attained peak during October and decreased thereafter due to non-availability of fresh food for the pest at the far end of the season. Anon. (2012) opined that rice leaffolder damage was more in DSR than the PTR.

Yellow stem borer

Per cent dead heart caused by YSB was noticed in vegetative phase of the crop, the maximum per cent dead heart was noticed the peak incidence of white ears was recorded in DSR (9.65%) followed by PTR (6.81%) under unprotected situation before harvest of the crop (Table 1). During *kharif* the maximum per cent dead heart was noticed in DSR under unprotected condition (8.55%) followed by PTR under unprotected (7.38%) during October the month of October. The per cent white ears was found high in DSR under unprotected condition (13.49%) compared to PTR under unprotected condition (11.26%) was prior to harvest of the crop (Table 4). Anon. (2012) who reported that yellow stem borer damage was high in DSR as compared to normal PTR method.

Green leafhopper

The green leafhoppers were active though out the crop period in *rabi* season and highest green leafhopper, *Nephotettix virescens* (Distant) population was (3.29/hill) recorded in PTR under unprotected situation during second fortnight of February (Table 1). During *kharif* green leafhopper appeared at 50 DAS of crop growth and attained their peak at 80 DAS and remained there up to maturity. Among the crop planting methods, the incidence level was comparatively high in PTR under unprotected situation (4.92 hoppers/hill) followed by DSR under unprotected condition (3.83 hoppers/hill) at 80 DAS (Table 5). The present findings are in conformation with Hegde and Nagappa (2011) and Anon (2012), who reported that the leafhopper population was significantly higher in PTR than aerobic methods.

Plant hoppers

Incidence of plant hoppers (BPH and WBPH), *Nilaparvata lugens* (Stal) and *Sogatella furcifera* (Horvath) was found to be more in PTR under unprotected situation in both the seasons during crop growth period. During *rabi* March second fortnight population of plant hopper was higher in unprotected PTR situation (5.21 and 4.67/hill) (Table 1). Whereas, in *kharif* peak population of plant hoppers found in PTR (28.90 and 18.44/hill) respectively, under unprotected situation (Table 6). Plant and leafhoppers population comparatively more in PTR than direct seeded rice mainly because of less application of irrigation water coupled with less usage of chemical fertilizer, these two are the important cultural factors which favour sucking pests menace in transplanted rice ecosystem. A few reports stated more plant hoppers in PTR fields than in DSR fields (Anon., 2010).

Natural enemies

Spider population (*Tetragnatha* sp and *Lycosa* sp) attained peak at reproductive phase of the crop and has maximum in PTR under unprotected condition (1.51/hill) followed by DSR unprotected condition (1.83/hill) at 90 days old crop during *rabi* (Table 2). Whereas, in *kharif* spider population attained highest level in transplanted rice under unprotected condition (1.51 adults/hill) reason for predominance of spider in PTR was more prey population which increased the spider population (Table 7). Mirid bug (*Cyrtohinus lividipennis* Reuter) population was significantly higher in PTR under unprotected situation in both the season (4.63 and 18.33 adults /hill) respectively. Coccinelid (*Coccinella transversalis* Fabricius) population reached peak (2.48/hill) during second fortnight of February during *rabi* (Table 2). Wherein, *kharif* season the Coccinellid beetle population was noticed maximum (1.96/hill) during second week of October in PTR under unprotected condition (Table 8). Activity of Staphylinids (*Paderus fuscips* Curtis) was found throughout the cropping period in both the season. There is a significant difference between the beetle population in DSR and PTR situation under unprotected condition. Present findings are in agreement with Anon (1988), who reported that the Staphylinid beetles were observed to the tune of one to three per hill in paddy ecosystem in Coimbatore district and their population was more during *rabi*/summer than *kharif* rice crop.

Correlation studies

Relationship between biochemical parameters with plant hoppers was assessed during *rabi* and *kharif* season respectively. The results revealed that total sugar content was more in PTR (23.04 and 18.24 mg/g) which was positively correlation (r= 0.936* and r= 0.296*) with plant hoppers during 90 days old crop respectively (Table 9b and 10b). Whereas, free phenols and soluble protein are lower which are negatively correlated with brown plant hoppers (r= -0.500**and r= -0.878*) and (r= -0.397* and r= -0.204*) respectively, in DSR, during 90 days old crop (Table 9b and 10b). Present findings are in line with Yolanda Chen (2009) and Chandramani *et al.* (2009) they reported high phenol content in rice is negatively correlated with the incidence of the whitebacked plant hoppers and brown plant hoppers.

Table 1. Status of insect-pests in direct seeded and transplanted rice ecosystems at Mallat village during *rabi* 2012-13

Observation period	Rice insect pests[#]						
	Ecosystem	Leaffolder damage (%)	Dead Heart (%)	White ear at pre harvest (%)	Green leaf hoppers/hill	BPH/ hill	WBPH/ hill
JAN II FN	Direct seeded rice	1.77	3.04	0.00	1.20	0.00	0.00
	Transplanted rice	1.11	1.15	0.00	1.45	0.00	0.00
	't' value	**1.04***	**3.07***	**0.00**	**2.24***	**0.00**	**0.00**
FEB I FN	Direct seeded rice	3.36	4.23	0.00	2.51	0.00	0.00
	Transplanted rice	1.89	2.77	0.00	3.20	0.00	0.00
	't' value	**2.89***	**5.35***	**0.00**	**4.06***	**0.00**	**0.00**
FEB II FN	Direct seeded rice	3.88	1.11	0.00	2.83	0.55	0.96
	Transplanted rice	2.47	0.95	0.00	3.29	0.84	1.56
	't' value	**1.79***	**2.44***	**0.00**	**3.09***	**1.26***	**2.89***
MAR I FN	Direct seeded rice	5.03	0.00	2.20	2.72	1.49	1.48
	Transplanted rice	4.18	0.00	0.92	2.86	1.87	2.39
	't' value	**2.16***	**0.00**	**2.12***	**5.29***	**3.64***	**4.61***
MAR II FN	Direct seeded rice	3.41	0.00	5.54	1.70	2.38	3.42
	Transplanted rice	1.90	0.00	4.30	2.20	5.29	4.67
	't' value	**2.48***	**0.00**	**2.19***	**3.39***	**1.16***	**7.68***
APR I FN	Direct seeded rice	2.08	0.00	9.01	1.38	1.37	2.69
	Transplanted rice	1.19	0.00	6.42	2.15	3.37	3.25
	't' value	**3.69***	**0.00**	**4.08***	**1.16***	**7.09***	**4.75***
APR II FN	Direct seeded rice	1.43	0.00	9.65	0.80	0.96	1.14
	Transplanted rice	0.96	0.00	6.81	1.32	2.30	2.44
	't' value	**3.05***	**0.00**	**4.53***	**4.22***	**5.82***	**5.75***

[#]Mean of 10 hills *Significant at 5% level, FN: Fort Night

Table 2. Status of predators in direct seeded and transplanted rice ecosystems at Mallat village during *rabi* 2012-13

Observation Period	Predators#				
	Ecosystem	**Spiders/hill**	**Mirid bugs/hill**	**Coccinellids/hill**	**Staphylinids/hill**
JAN I FN	Direct seeded rice	0.20	0.00	0.68	0.00
	Transplanted rice	0.32	0.00	0.93	0.00
	't' value	**NS**	**0.00**	**1.96***	**0.00**
JAN II FN	Direct seeded rice	0.42	0.00	1.31	0.00
	Transplanted rice	0.47	0.00	1.26	0.00
	't' value	**NS**	**0.00**	**NS**	**0.00**
FEB I FN	Direct seeded rice	0.60	0.00	1.44	1.82
	Transplanted rice	0.88	0.00	1.90	1.40
	't' value	**1.83***	**0.00**	**1.64***	**0.90**
FEB II FN	Direct seeded rice	0.70	0.73	2.16	2.66
	Transplanted rice	0.90	1.13	2.48	2.18
	't' value	**1.97***	**NS**	**1.54***	**1.21***
MAR I FN	Direct seeded rice	0.89	1.28	1.80	1.23
	Transplanted rice	1.10	1.87	2.01	0.94
	't' value	**2.55***	**NS**	**NS**	**0.99***
MAR II FN	Direct seeded rice	1.23	3.45	1.53	0.00
	Transplanted rice	1.60	4.63	1.74	0.00
	't' value	**2.35***	**1.69***	**1.12***	**0.00**
APR I FN	Direct seeded rice	1.18	1.90	1.29	0.00
	Transplanted rice	1.30	2.10	1.32	0.00
	't' value	**NS**	**1.37***	**NS**	**0.00**

Table 3. Incidence of leaffolder in direct seeded and transplanted rice ecosystems at ARS, Gangavathi during *kharif* 2013

Treatments	Per cent leaffolder damage at different crop stages*							
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS
Direct seeded rice protected condition	2.77 (9.58)	3.44 (10.69)	3.71 (11.11)	4.16 (11.77)	5.21 (13.19)	5.44 (13.49)	4.62 (12.41)	3.39 (10.61)
Direct seeded rice unprotected condition	3.84 (11.29)	5.16 (13.12)	7.78 (16.20)	8.50 (16.95)	11.29 (19.63)	13.01 (21.14)	9.31 (17.77)	7.16 (15.52)
Transplanted rice protected condition	1.86 (7.85)	2.46 (9.06)	2.98 (9.93)	3.61 (10.95)	4.11 (11.69)	4.36 (12.05)	3.40 (10.62)	2.55 (9.19)
Transplanted rice unprotected condition	2.11 (8.36)	3.51 (10.80)	4.27 (11.92)	5.27 (13.27)	7.21 (15.57)	9.48 (17.93)	7.12 (15.48)	5.34 (13.36)
S.Em±	0.18	0.16	0.12	0.11	0.19	0.16	0.21	0.11
CD @ 5%	0.57	0.51	0.37	0.33	0.59	0.49	0.65	0.35

* Mean of 10 hills DAS: Day After Sowing

Figures in parenthesis are arc sin transformed values

Table 4. Incidence of yellow stem borer in direct seeded and transplanted rice ecosystems at ARS, Gangavathi during kharif 2013

Treatments	Per cent dead heart in different crop stages*				Per cent white ear at pre harvest
	40 DAS	50 DAS	60 DAS	70 DAS	
Direct seeded rice protected condition	1.84 (7.79)	3.81 (11.26)	5.69 (13.80)	4.13 (11.73)	9.20 (17.65)
Direct seeded rice unprotected condition	3.55 (10.86)	6.26 (14.49)	8.55 (17.00)	7.35 (15.73)	13.49 (21.55)
Transplanted rice protected condition	0.94 (5.57)	2.62 (9.32)	4.30 (11.97)	3.25 (10.39)	7.20 (15.56)
Transplanted rice unprotected Condition	1.33 (6.63)	5.00 (12.92)	7.38 (15.76)	5.24 (13.24)	11.76 (20.05)
S.Em±	0.21	0.06	0.12	0.07	0.20
CD @ 5%	0.65	0.18	0.36	0.22	0.62

*Mean of 10 hills DAS: Day after Sowing
Figures in parenthesis are arc sin transformed values

Table 5. Incidence of green leafhopper in direct seeded and transplanted rice ecosystems at ARS, Gangavathi during kharif 2013

Treatments	Green leafhoppers/hill at different crop stages*					
	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS
Direct seeded rice protected condition	0.30 (0.89)	0.86 (1.17)	1.09 (1.26)	1.72 (1.49)	1.24 (1.32)	0.82 (1.15)
Direct seeded rice unprotected condition	0.72 (1.10)	1.05 (1.24)	2.40 (1.70)	3.83 (2.64)	2.96 (1.86)	1.88 (1.54)
Transplanted rice protected condition	0.89 (1.18)	1.30 (1.34)	1.92 (1.56)	2.56 (1.75)	2.10 (1.90)	1.28 (1.67)
Transplanted rice unprotected condition	1.25 (1.32)	2.07 (1.57)	3.58 (2.02)	4.92 (2.33)	3.73 (2.06)	2.26 (1.94)
S.Em±	0.014	0.013	0.010	0.031	0.031	0.050
CD @ 5 %	0.042	0.041	0.038	0.102	0.096	0.155

*Mean of 10 hills, DAS: Day After Sowing
Figures in parenthesis are square root transformed ($\sqrt{x + 0.5}$) values

Table 6. Incidence of plant hoppers in direct seeded and transplanted rice ecosystems at ARS, Gangavathi during kharif 2013

Treatments	Brown planthoppers/ hill at different crop stages*						Whitebacked planthoppers/ hill at different crop stages*					
	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	110 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	110 DAS
Direct seeded rice protected condition	2.22 (1.65)	5.38 (2.42)	6.30 (2.79)	8.05 (2.92)	5.10 (2.37)	5.22 (2.39)	0.90 (1.18)	2.32 (1.68)	5.24 (2.40)	7.38 (2.81)	4.36 (2.20)	2.06 (1.60)
Direct seeded rice unprotected condition	3.32 (1.95)	7.92 (2.90)	11.36 (3.44)	12.12 (3.55)	11.02 (3.99)	8.60 (3.02)	1.38 (1.37)	4.08 (2.14)	10.23 (3.28)	11.30 (3.44)	6.50 (2.65)	3.42 (1.98)
Transplanted rice protected condition	4.24 (2.18)	8.08 (2.93)	8.96 (3.08)	9.34 (3.14)	7.48 (2.88)	7.05 (3.40)	2.18 (1.64)	5.24 (2.40)	8.28 (2.96)	9.20 (3.11)	7.96 (2.91)	4.02 (2.13)
Transplanted rice unprotected condition	7.54 (2.84)	11.58 (3.48)	15.90 (3.95)	28.90 (5.42)	16.08 (4.19)	13.16 (3.70)	4.74 (2.29)	9.83 (3.21)	16.88 (4.17)	18.44 (4.35)	9.12 (3.10)	6.51 (2.65)
S.Em±	0.030	0.035	0.020	0.008	0.030	0.021	0.039	0.007	0.019	0.038	0.017	0.031
CD @ 5%	0.088	0.109	0.061	0.024	0.095	0.052	0.121	0.022	0.058	0.091	0.051	0.097

* Mean of 10 hills, DAS: Day after Sowing Figures in parenthesis are square root transformed ($\sqrt{x + 0.5}$) values

Table 7. Status of predators in direct seeded and transplanted rice ecosystems at ARS, Gangavathi during kharif 2013

Treatments	Spiders per hill at different crop stages*							Mirid bugs per hill at different crop stages*			
	40 DAS	**50 DAS**	**60 DAS**	**70 DAS**	**80 DAS**	**90 DAS**	**100 DAS**	**70 DAS**	**80 DAS**	**90 DAS**	**100 DAS**
Direct seeded rice protected condition	0.16 (0.81)	0.27 (0.88)	0.40 (0.95)	0.45 (0.97)	0.86 (1.17)	0.62 (1.06)	0.70 (1.10)	3.51 (2.00)	6.24 (2.60)	8.33 (2.97)	6.09 (2.57)
Direct seeded rice unprotected condition	0.30 (1.32)	0.48 (0.99)	0.75 (1.12)	0.82 (1.15)	1.51 (1.42)	1.05 (1.24)	1.21 (1.41)	8.56 (3.01)	10.26 (3.28)	14.54 (3.88)	7.39 (2.81)
Transplanted rice protected condition	0.18 (0.82)	0.28 (0.88)	0.43 (0.96)	0.50 (1.00)	0.90 (1.18)	0.66 (1.08)	0.75 (1.18)	3.60 (2.02)	8.54 (3.01)	9.38 (3.14)	6.18 (2.58)
Transplanted rice unprotected condition	0.55 (1.02)	0.60 (1.05)	1.07 (1.25)	1.17 (1.29)	1.83 (1.53)	1.33 (1.35)	1.53 (1.42)	10.85 (3.37)	16.04 (4.07)	18.37 (4.34)	9.34 (3.14)
S.Em±	0.008	0.008	0.011	0.020	0.015	0.017	0.029	0.042	0.053	0.033	0.035
CD @ 5 %	0.025	0.028	0.033	0.065	0.048	0.053	0.091	0.129	0.164	0.101	0.110

*****Mean of 10 hills DAS**:** Day After Sowing Figures in parenthesis are square root transformed ($\sqrt{x + 0.5}$) values

Table 8 Status of predators in direct seeded and transplanted rice ecosystems at ARS, Gangavathi during *kharif* 2013

Treatments	Coccinellids per hill at different crop stages*							Staphylinids per hill at different crop stages*		
	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	60 DAS	70 DAS	80 DAS
Direct seeded rice protected condition	0.13 (0.79)	0.18 (0.82)	0.21 (0.84)	0.30 (0.89)	0.27 (0.88)	0.20 (0.84)	0.16 (0.81)	0.19 (0.83)	0.26 (0.87)	0.22 (0.85)
Direct seeded rice unprotected condition	0.33 (0.91)	0.66 (1.08)	0.92 (1.19)	1.34 (1.36)	0.76 (1.12)	0.44 (0.97)	0.68 (1.09)	0.42 (0.96)	0.55 (1.02)	0.31 (0.90)
Transplanted rice protected condition	0.15 (0.81)	0.19 (0.83)	0.20 (0.84)	0.34 (0.94)	0.30 (0.89)	0.22 (0.85)	0.17 (0.82)	0.16 (0.81)	0.23 (0.85)	0.17 (0.82)
Transplanted rice Unprotected condition	0.50 (1.00)	0.92 (1.19)	1.61 (1.45)	1.96 (1.45)	1.06 (1.57)	0.51 (1.00)	0.82 (1.15)	0.31 (0.90)	0.41 (0.97)	0.21 (0.84)
S.Em±	0.006	0.048	0.006	0.017	0.011	0.010	0.005	0.015	0.015	0.022
CD @ 5 %	0.021	0.015	0.019	0.052	0.035	0.032	0.017	0.047	0.046	0.067

*****Mean of 10 hills DAS**:** Day After Sowing Figures in parenthesis are square root transformed $(\overline{\sqrt{x} + 0.5})$ values

Table 9a. Influence of different planting methods on the biochemical parameter of rice plants during *rabi* 2012-13

Ecosystem	*kharif* 2013								
	Total sugar (mg)			Free phenols (mg)			Soluble protein (mg)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Direct seeded rice	16.14	18.52	21.33	2.08	1.89	1.34	5.18	4.26	3.31
Transplanted rice	17.26	19.73	23.04	1.94	1.47	1.15	4.52	3.76	2.74

DAS: Day After Sowing

Table 9b. Correlation between biochemical parameter of rice plants and incidence of insect-pests during *rabi* 2012-13

Ecosystem	Total sugars (mg)				Free phenols (mg)				Soluble protein (mg)			
	60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS	
	BPH/ hill	WBPH / hill	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH / hill	BPH/ hill	WBPH / hill	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH / hill
Direct Seeded rice	0.875	0.847	0.927	0.892	- 0.300*	-0.526*	- 0.500**	- 0.908**	-0.158*	-0.533*	- 0.397*	-0.815*
Trans planted rice	0.981* *	0.881*	0.954*	0.936*	-0.656	-0.766	-0.969	-0.967	-0.469	-0.811	-0.806	-0.778

DAS : Day After Sowing ** Significant at P = 0.01 *Significant at P = 0.05

Table 10 a. Influence of different planting methods on the biochemical parameter of rice plants during *kharif* 2013

Ecosystem	*kharif* 2013								
	Total sugar (mg)			Free phenols (mg)			Soluble protein (mg)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Direct seeded rice	12.56	14.83	17.06	2.18	1.75	1.43	4.90	3.35	2.82
Transplanted rice	13.27	16.28	18.24	1.81	1.23	1.08	4.12	3.20	2.41

DAS: Day after Sowing

Table 10 b. Correlation between biochemical parameter in rice plants and incidence of insect-pests during *kharif* 2013

Ecosystem	Total sugars (mg)				Free phenols (mg)				Soluble protein (mg)			
	60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS	
	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH/ hill	BPH/ hill	WBPH/ hill
Direct seeded rice	0.731	0.873	0.866	0.892	-0.522*	-0.701*	-0.878*	-0.810*	-0.986**	-0.859*	-0.204*	-0.814*
Transplanted rice	0.834*	0.990**	0.713**	0.296*	-0.683	-0.946	-0.931	-0.998	-0.643	-0.126	-0.831	-0.375

DAS: Day After Sowing ** Significant at P = 0.01 *Significant at P = 0.05

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