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Impact of crop establishment methods on rice insect pests incidence in Indo Gangetic Plain (IGP)

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ABSTRACT

Rice (*Oryza sativa* L.), is the staple food for more than half of the world population and an important target to secure food security and livelihoods for millions. The production of rice to mitigate the consumption requirement needs huge amount of water. Direct seeded rice (DSR) technique is becoming popular nowadays because of its low-input demands and potential to maximize the water productivity under deficit soil moisture. Rice variety, Pusa 1121 is important variety in major rice growing areas of Indo Gangetic Plain that occupies more than 70% area. The population of planthoppers and stem borers were significantly higher and appeared early in direct seeding crop as compared with transplanted rice (TPR). The mean seasonal incidence of stem borers in 2014 were 9.58 and 5.29% in direct seeding whereas in 2015 it was 9.36 and 4.97%. The damage (white ears) was observed maximum on 42nd week in October. The result revealed that incidence of leaffolder was significantly higher in direct seeding than transplanting. The population/ incidence of pests showed positively significant correlation with biotic factors during the study. The grain yield in transplanting crop was also significantly higher than direct seeding. So, management practices in direct seeding should be practiced earlier as compared to transplanted rice to maximize yield by reducing pest population pressure for sustainable agriculture and to conserve natural resources.

Key words: Biotic, Direct seeding, Pests, Rice, Transplanting

More than 100 species of insects are known to attack the rice crop. Among these, stem borers, leaffolder, planthoppers, gall midge, whorl maggot, gundhi bug, caseworm, rice hispa, armyworm and thrips are the most important in India and other countries (Krishanaiah *et al*. 2008).

Rice is cultivated by various methods in different parts of the world. The most common methods are direct sowing (dry direct seeding and wet direct seeding) and transplanting in rice (Kuotsuo *et al*. 2014, Chatterjee *et al*. 2016, Kumar *et al*. 2016, Kumar *et al*. 2017). Water and labour are two major drivers of agricultural change worldwide because rice cultivation requires huge amount of water and is labour intensive. These two factors have already affected the development of rice based agricultural system in the past and will remain the main factors for future. Although rice cultivation by transplantation is generally considered the superior method, direct sowing has been successful in some parts of the world (Adair *et al*. 1992, Weerakoon *et al.* 2011), as it saves both labour and water. Direct seeding reduces the labour required for the cultivation of transplanted rice by half. This technique also reduces the total labour requirement by 11-66% compared to puddled transplanted rice depending on season, location, and type of cultivation method (Kumar *et al*. 2009). Farmers have great enthusiasm towards direct seeded rice because of labour shortage and water scarcity favours the adoption of direct seeding technology in replacement of traditional labour intensive transplanting (Azami and Baki 2007, Prakash *et al*. 2014, Kumar *et al.* 2015a, Kumar *et al*. 2016, Kumar *et al*. 2016a, b, Singh *et al*. 2017). Kumar and Ladha (2011) reported the benefits of direct seeding as it improves the soil health, emits less methane and often ensure higher profit in area with assured irrigation supply. Methane emitted from paddy soils can be controlled by various management practices such as reducing the number of irrigations, multiple drainage system during the crop cycle, alternate wetting and drying, *Azolla* application and semi-dry cultivation (Zhao *et al*. 2006). Agriculture sector alone contributes more than half (50.63%) of the anthropogenic CH_4 emissions at the global level out of which rice paddy fields contribute about 20% (Ke *et al.* 2014, Lo *et al*. 2016, Malyan *et al.* 2016).

The farmers along with the benefits of direct seeding also complaining the yield gap as compared to transplanting method because of weeds, insect pests and diseases. Direct seeding method due to its early establishment in field

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attract more insect pests as habitat and to colonize earlier as compared to transplanting method (Savary *et al*. 2005, Sarao and Mahal 2013, Karthikeyan *et al*. 2014, Ashrith *et al.* 2016). This variety has a great significance and grown in major rice growing areas of Indo Gangalic Plain i.e Haryana, Punjab, Uttar Pradesh, Uttarakhand, Jammu & Kashmir and Himachal Pradesh. The total area sown under basmati rice was 15.60 mha out of which 11.01 mha represents 70.57 per cent area under Pusa 1121 (APEDA 2017). So the pest complex was not studied under different crop establishment methods on this variety. The important factors influencing the pest status in DSR is exposure of very young seedlings to pests, more plant density and longer plant duration in the field. The nursery raised for transplanting takes approx 30 days in nursery and after uprooting the seedling for transplanting it takes 15 days in root development after losing their vigour and colour intensity which makes them unattractive for pests to colonize and pest prefer DSR. Rice stubbles after crop harvest usually serve as the main overwintering sites for rice stem borers may also affect damage status in direct sown rice (Wu *et al*. 2014). So the study is important to know the status of pests in different cultivation methods as the cultural/ agronomical practices and the microclimate in transplanting method is different from direct seeding method of rice cultivation which might affect the insect pest abundance/ incidence (DRR 2011-2012). It includes decisions on variety to be grown, time and method of sowing, tillage operations, field and crop sanitation, application of fertilizers and irrigation, harvesting times and methods along with off-season operations in fallow/cropped fields.

The purpose and novelty of the present article is much more specific, focusing on two particular production factors, their likely evolution and their possible influence on rice pests under majorly growing basmati variety Pusa 1121. Here, our emphasis is on the description of effects of agricultural change, driven by water and labour availability on rice pest. The results of present study showed the significance as the management practices should be practiced earlier as compared to transplanted rice to reduce initial pest population size as many insects have overlapping generations that may cause damage up to harvesting.

MATERIALS AND METHODS

To study the effect of two crop establishment methods, one acre (4000 m^2) plot was divided into two equal halves one each for direct seeding and transplanting at CCSHAU-Hisar, India.

Rice variety Pusa 1121 was sown by seed drill in rows 20 cm apart at a seed rate of 20 kg/ha during second week of June in both the years (2014 and 2015) in a dry well prepared and levelled seed bed. The field was irrigated immediately after sowing to ensure seed germination. For controlling weeds, pre-emergence application of pendimethalin @ 1000g a.i/ha was done after 3 days of sowing. The post emergence herbicide bispyribac sodium (10% SC) was sprayed at the rate of 25g a.i/ha at 25 days after sowing.

The nursery of variety Pusa 1121 was sown during second week of June during both the years on the same day when the direct seeding was done in direct seeding method. The transplanting of 25 days old seedlings was carried out in well puddled field at a spacing of 20×15 cm with 2 seedlings/hill. Each plot (direct seeding and transplanting) was divided into 5 blocks/replicates of 400 m^2 area each. The recommended agronomic practices (Anonymous 2013a) were followed to raise the crop under both crop establishment methods and no pesticide was applied till the harvest of the crop.

Population/incidence of different insect pests and natural enemies was recorded from 10 randomly selected hills in each block at 7 days interval from 40-45 days after sowing till harvest.

Foliage feeders: Total leaves and damaged leaves were recorded to compute per cent damaged leaves

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

Borers: Total tillers and dead hearts at vegetative stage and white ears at reproductive stage were counted to compute per cent dead hearts and white ears as under

$$\text{Per cent dead hearts} = \frac{\text{Number of dead hearts counted}}{\text{Total number of tillers observed}} \times 100$$

$$\text{Per cent white ears} = \frac{\text{Number of white ears}}{\text{Total productive tillers}} \times 100$$

Sucking pests and natural enemies: The population of planthoppers along with predators (spiders & mirids) were recorded in the forenoon visually.

Yield: Grain yield of the crop was recorded at harvest from a small plot of 5m×4m in each block/replicate.

Statistical analysis: The data obtained in different crop establishment methods on incidence of insect pest and natural enemies were tabulated and statistically analyzed by comparing means with independent sample t-test (Z- test) by using IBM SPSS 19.0 version. Correlation of population fluctuations of insect pests with different meteorological parameters and natural enemies was worked out.

RESULTS AND DISCUSSION

Effect of crop establishment methods on population of planthoppers

The data on population of planthoppers under different crop establishment methods is presented in Table 1. The population of planthoppers in the present study started to colonize early in direct seeded with a few individuals in last week of July as compared to transplanting during both the years. The study revealed that overall population of planthoppers was significantly higher in direct seeded rice during the study (Savary *et al*. 2005, Sarao and Mahal

Table 1 Effect of crop establishment methods on population of planthoppers (*Nilaparvata lugens* and *Sogatella furcifera*) during *kharif* 2014 and 2015

Month	Standard meteorological weeks	Planthoppers (mixed population)/hill					
		2014			2015		
		Direct seeding	Transplanting	t-value	Direct seeding	Transplanting	t-value
July	31	0.14	0.00	2.45**	0.00	0.00	0.00
August	32	0.22	0.00	2.85**	0.42	0.00	4.06**
August	33	0.62	0.34	2.28*	0.82	0.31	2.36*
August	34	1.04	0.54	2.73**	2.04	1.28	3.30**
August	35	2.52	1.74	3.65**	7.16	5.92	5.79**
September	36	2.04	1.44	3.09**	9.04	7.64	4.68**
September	37	3.66	2.94	4.45**	16.86	14.92	4.17**
September	38	5.22	4.23	5.87**	10.64	9.70	2.59**
September	39	3.60	2.74	2.81**	10.02	8.82	4.24**
October	40	7.26	5.82	6.32**	16.96	15.62	3.30**
October	41	3.20	2.50	2.12*	10.24	8.50	5.59**
October	42	1.80	1.28	2.07*	9.08	7.58	5.87**
Seasonal Mean		2.61	1.96		7.77	6.69	

**Significant at 1% level of significance, * Significant at 5% level of significance

2013, Soni and Tiwari 2016). The planthoppers/hill increase gradually in September and reached to a maximum population density in October. Several researchers have suggested that high seeding rate for drill method leads to close spacing, consequent dense crop stand and closer plants establishment because of less plant to plant distance by modifying the micro climate favorable for multiplication and build up of planthoppers population (Nik and Hirao 1987, Wada 2000, Savary *et al*. 2005).

The correlation study showed the population of planthoppers has significant and positive relationship with spiders and mirids (Table 3). These results are strongly supported by Rajna and Chander (2013) who reported the spiders and mirid bugs were found more abundant during pre-flowering and post flowering crop stage, respectively and indicating to conserve natural enemies in and around the field. The earlier application of control measures along with bio control agents and cultural practices helps to reduce initial pest population build up.

Effect of crop establishment methods on incidence of rice stem borers

The infestation of stem borers was observed one to two week earlier in direct seeded rice. The infestation commenced during 34th and 35th week in August in direct seeding and transplanting crop during 2014. The mean

Table 2 Effect of crop establishment methods on incidence of rice stem borers during *kharif* 2014 and 2015

Month	Standard meteorological weeks	Dead hearts (%)/ white ears (%)					
		2014			2015		
		Direct seeding	Transplanting	t-value	Direct seeding	Transplanting	t-value
August	34	2.27	0.0	2.69**	0.0	0.0	0.0
August	35	5.14	1.44	2.16*	2.05	0.0	2.7**
September	36	5.53	1.91	2.33*	6.37	2.92	1.91*
September	37	4.88	2.12	2.11*	8.48	4.31	2.03*
September	38	7.61	3.63	2.29*	10.65	5.92	2.17*
September	39	12.62	7.86	2.08*	11.21	5.99	2.08*
October	40	12.52	6.61	2.52**	12.28	6.9	2.14*
October	41	16.16	10.39	2.14*	11.03	6.28	1.91*
October	42	19.50	13.67	2.10*	12.87	7.49	1.99*
Seasonal mean		9.58	5.29		9.36	4.97	

**Significant at 1% level of significance, * Significant at 5% level of significance

Table 3 Correlation of rice leaffolder and stem borer incidence on rice with biotic factor during *kharif* 2014 and 2015

Biotic factors (Spider)	2014		2015	
	Direct seeding	Transplanting	Direct seeding	Transplanting
Rice leafolder	0.214	0.788**	0.711*	0.378
Stem borer	0.379	0.724*	0.715*	0.442
Planthoppers	0.602*	0.654*	0.731**	0.652*
Mirid bugs (Planthoppers)	0.670*	0.671*	0.596*	0.585*

**Significant at 1% level of significance, * Significant at 5% level of significance

seasonal incidence was significantly higher in direct seeding (Table 2). However, infestation was noticed one to two week later during 2015 compared to previous year with corresponding values of 9.36 and 4.97% in direct seeding and transplanting. The infestation increased in succeeding weeks and found significantly higher in direct seeding than transplanting method during the study (Oyedrin and Heinrich 2001, Savary *et al*. 2005, Ashrith *et al*. 2016). A multi-location trial of AICRIP at Pusa and Raipur, the infestation of stem borer was also significantly higher in direct sown rice while no significant difference at Rajendranagar (Anonymous 2012). In direct seeded field due to lack of plant to plant spacing , the plants were in close proximity leads to easy movement of larvae from one plant to another cause severe damage. The close planting of rice seedlings has also been validated to increase stem borer damage (Sharma *et al.* 1995, Sarao and Mahal 2006). Secondly, rice stubbles after harvest serve as the main overwintering sites for borers in DSR as compared to transplanted because of puddling during field preparation may reduce the chance of initial pest buildup by mortality of overwintered larvae (Xu *et al*. 2015, Xu *et al*. 2017). The ploughing and irrigation significantly decrease the initial population sizes of stem borers up to 70 per cent this is another reason for less incidence of borers in TPR (Guo *et al.* 2013a).

Incidence of stem borers was positively correlated with spiders under both the methods (Larter 1955). However, several researchers has reported non significant damage of stem borers in both the methods and that may be due to changes in ecological conditions, variety or pest status during the season (Baloch and Abdullah 2011, Kaur and Singh 2015, Soni and Tiwari 2016).

Effect of crop establishment methods on incidence of rice leaffolder

The incidence of leaffolder (*Cnaphalocrocis medinalis*) was reported from tillering to panicle initiation with more number of damaged leaves in DSR during both the years. The leaffolder damage varied from 4.51 to 8.32 and 2.19 to 6.41% damaged leaves in different weeks in direct seeding and transplanting method during 2014 while in 2015 incidence ranged from 2.54 to 6.55 and 1.10 to 4.64% damaged leaves in both the methods respectively. The mean seasonal incidence was significantly higher in direct seeding than transplanting during the study (Table 4). The higher incidence of leaffolder in direct seeded rice as compared to transplanted rice has been reported due to early establishment of crop attract moths of pest to colonies as selection pressure and easy movement of larvae due to higher vegetative biomass (Savary *et al.* 2005, Mahajan

Table 4 Effect of crop establishment methods on incidence of rice leaffolder, *Cnaphalocrocis medinalis* during *kharif* 2014 and 2015

Month	Standard meteorological weeks	Damaged leaves (%)					
		2014			2015		
		Direct seeding	Transplanting	t-value	Direct seeding	Transplanting	t-value
August	33	4.51	2.19	2.14*	2.54	1.10	1.91*
August	34	6.57	3.92	2.03*	3.83	2.02	2.09*
August	35	8.32	6.41	2.27*	4.06	2.65	1.90*
September	36	7.31	6.33	2.17*	6.43	4.58	1.96*
September	37	6.83	5.45	2.70**	5.33	3.81	2.07*
September	38	7.70	6.36	2.13*	5.55	4.19	2.32*
September	39	7.21	5.26	2.77**	6.19	4.64	2.10*
October	40	7.27	5.17	2.98**	6.00	4.20	2.25*
October	41	6.76	4.95	2.98**	6.55	4.63	2.14*
October	42	4.91	3.56	2.43**	5.36	3.76	2.29
Seasonal mean		6.73	4.96		5.18	3.55	-

**Significant at 1% level of significance,* Significant at 5% level of significance

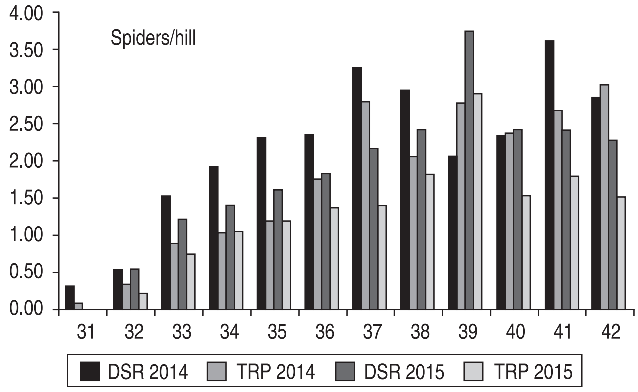

Fig 1 Effect of crop establishment methods on population of spiders during *kharif* 2014 and 2015.

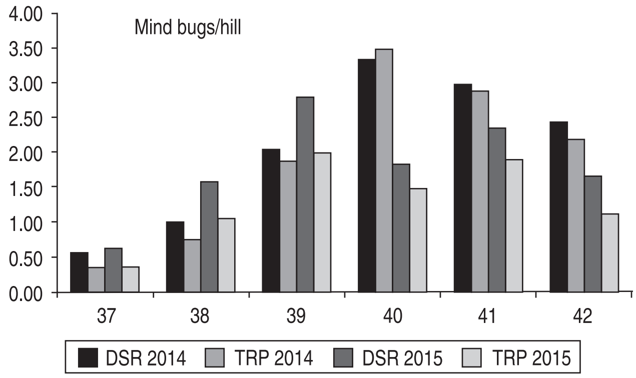

Fig 2 Effect of crop establishment methods on population of mirid bugs during *kharif* 2014 and 2015.

and Sarao 2009, DRR 2011-2012, Karthikeyan *et al*. 2014). These results are also supported by Weerakoon *et al*. (2011) who reported that the leaffolder infestation was higher in direct seeded rice crops in Sri Lanka during two cropping seasons as compared to system of rice intensification. The study is not in conformity with Kaur and Singh (2015) that the stem borer and leaf folder damage was not affected by different crop establishment methods. In Table 3, the results showed the spiders were observed to predate upon the larvae and adults of leaffolder and showed positive correlation with leaffolder incidence (Netam and Gupta 2015). As the result indicated positive correlation of spiders with leaffolder may reduce initial pest population by conserving natural enemies through habitat manipulation and agronomic interventions.

Effect on population of spiders, mirid bugs and grain yield

The population of natural enemies was noticed earlier in direct seeded and continued throughout the cropping season (Fig 1 and 2). The mean seasonal population of 2.17 spiders/hill in direct seeding and 1.76 spiders/hill in transplanting and was significantly higher in direct seeding during 2014. Whereas in 2015, spiders colonized one week later than the preceeding year, i.e in 32nd week in August. The mean seasonal population was also significantly higher in direct seeded (1.84/hill) than transplanted (1.30/hill) rice.

The bugs population start to appear in 37th week and continued till harvest, i.e from second week of September to throughout the season during both the years. The seasonal mean population was differed non significantly with higher population in direct seeded (2.07/hill) to transplanted (1.93/hill) during 2014. The population fluctuation of mirids over the observation weeks was differed significantly as well as at par with each other in different weeks in 2015. The seasonal mean population differed significantly during and found higher in direct seeding (1.82/hill) than transplanting (1.33/hill).

The overall population of predators was significantly higher in direct seeded rice due to availability of plenty of food/host (Gowda and Gubbiah 2011, Rajna and Chander 2013)

This is inferred from data the grain yield of rice was significantly influenced by crop establishment methods. There was significant difference in grain yield in two crop establishment methods. The highest grain yield was recorded in transplanted crop as compared to direct seeding. Several researchers worldwide have dealt with yield performance and water use efficiency in direct seeded rice, but they reported variable yield response depending upon type of cultivar and location (Kato *et al.* 2009). The leaffolder, stem borers and sucking insects appeared earlier and at a high intensity in direct seeded rice caused significant yield losses (Oyedrin and Heinrichs 2001, Sarao and Mahal 2013).

From the above investigation, demonstrates that direct seeding of rice reduces water requirement, labour requirement and methane emission. The infestation of major pests during the study was recorded significantly higher in direct seeded due to early establishment, higher vegetative biomass and lack of plant to plant distance facilitates easy movement of immature stages for feeding and attract more pests to colonies as initial pest outbreak leads to significant difference in yield gap as compared to transplanting. The conclusion of result indicating towards pre planning of DSR to be sown area to reduce survived stem borers from stubbles and after sowing thinning at early stage to maintain plant to plant distance along with natural enemies conservation and need based application of chemicals. Hence direct seeded technology improve water productivity and its adoption is a dire need to conserve natural resources and the limitations associated could be overcome by mechanizing the system. Adoption of suitable control measures earlier as compared to transplanted rice will be helpful to reduce initial pest outbreak. Local environmental conditions and cultural practices may alter the response of pests under different crop establishment methods.

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