Direct and Indirect Effects of Planting Density, Nitrogenous Fertilizer and Host Plant Resistance on Rice Herbivores and Their Natural Enemies

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Table S1. Planthoppers and leafhoppers captured during blow-vac sampling in the dry and wet seasons according to subplot variety, transplanting density and nitrogen levels.

Variety[1]	**IR62**	**IR62**	**IR62**	**IR64**	**IR64**	**IR64**	**IR62**	**IR62**	**IR62**	**IR64**	**IR64**	**IR64**
Density[2]	**HD**	**HD**	**HD**	**HD**	**HD**	**HD**	**LD**	**LD**	**LD**	**LD**	**LD**	**LD**
Nitrogen[3]	**0**	**60**	**150**	**0**	**60**	**150**	**0**	**60**	**150**	**0**	**60**	**150**
Dry season												
Cicadulina bipunctata						1						
Cofana spectra					1				1			
Nephottetix malayanus								1			1	
Nephottetix nigropictus	1	5	2	2	6	9				1	3	3
Nephottetix viriscens	28	30	17	87	72	56	23	12	18	69	50	53
Recilia dorsalis			1		2	1		1		1	1	1
Scaphoideus morosus									1			
Nilaparvata lugens	27	36	48	28	57	111		14	1	3	4	
Sogatella furcifera	28	26	73	59	140	152	88	142	192	84	208	245
Sogatella kolophon				1								
Tagosodes sp 1		1	3	2	3	2		3	1			1
Total	84	98	144	179	281	332	111	173	214	158	267	303
Species richness	4	5	6	6	7	7	2	6	6	5	6	5
Wet season												
Balclutha sp.									1			1
Cicadulina bipunctata	1	2	2	3	1	3	5		1	2	1	
Cofana spectra		1		3	1	2				1	1	1
Empoascanara sp.										1		
Hortensia sp.								1		1		
Nephottetix malayanus	7		4	5	1	4	3	2	2	6	2	
Nephottetix nigropictus	13	15	18	53	37	28	19	30	12	33	21	47
Nephottetix viriscens	38	27	63	75	82	56	51	109	71	62	31	63
Nephotettix sp.								1	1	1		1

Recilia dorsalis	3	4	2	6	7	18	5	6	4	4	4	4
Unidentified												1
Zyginidia sp.				1						1	1	5
Nilaparvata bakeri			2									
Nilaparvata lugens	10	40	92	53	68	116	44	22	44	42	62	57
Sogatella furcifera	142	89	88	209	151	176	116	266	148	162	96	125
Sogatella kolophon				2	1	1	2			2	1	1
Tagosodes sp 1		15	2	2	3	8	2	2	2	4	4	1
Tagosodes pusanus	1			1	1	1		2		3	2	1
Nisia sp. *(near) nervosa*			3					1			1	
Total	213	192	274	411	351	409	245	439	283	320	223	303
Species richness	8	8	10	12	11	11	9	11	10	15	13	13

[1]: IR62 is resistant to planthoppers and leafhoppers; [2]: HD = high-density planting (10 × 10cm), LD = low-density planting; [3]: 0 = 0 N added, 60 = 60 Kg N added ha^{-1}, 150 = 150 Kg N added ha^{-1}

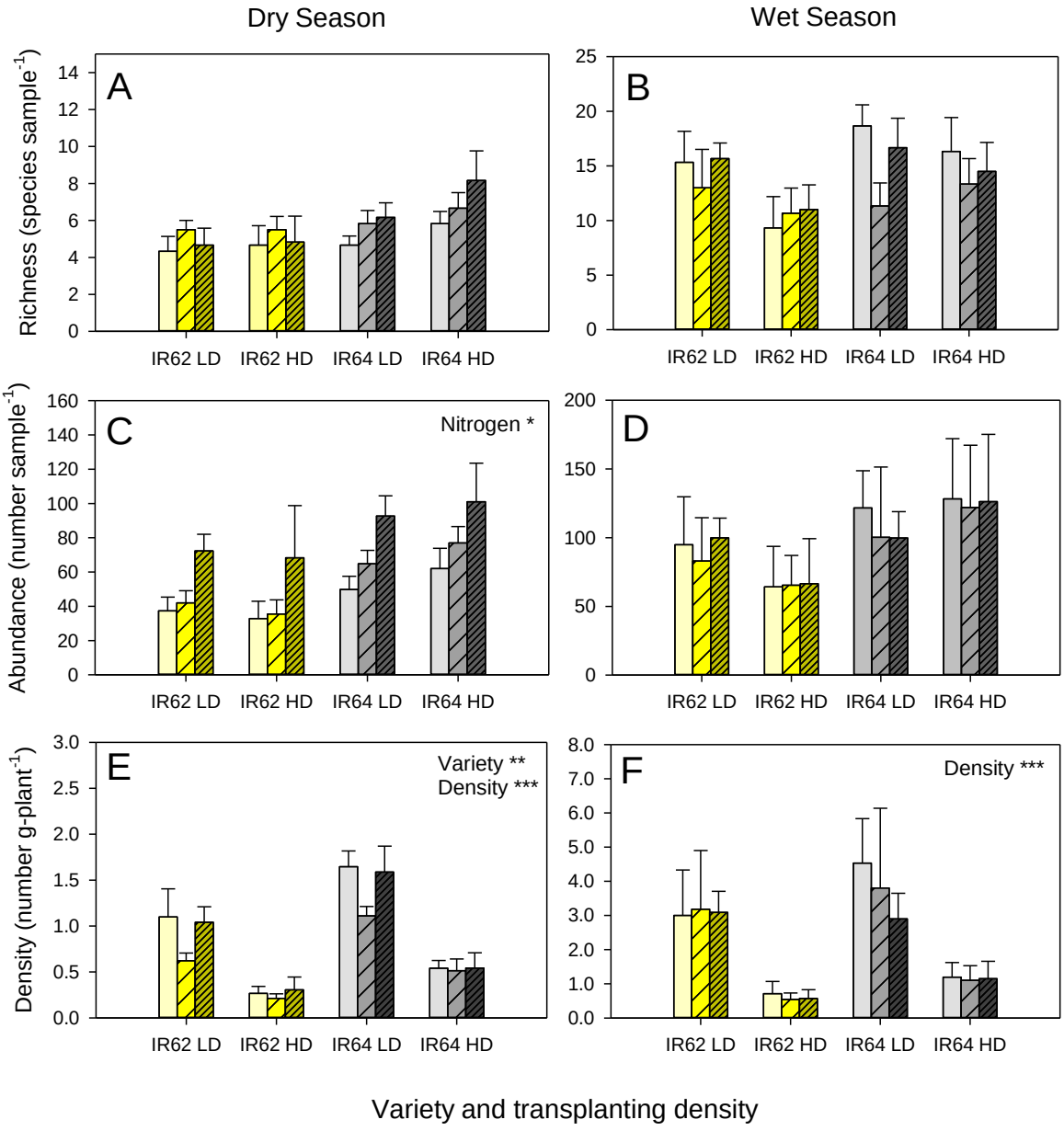

Figure S1. Species richness (**A,B**), abundance (**C,D**) and density (**E,F**) of herbivores (all species combined) in rice plots with resistant (IR62: yellow bars) and susceptible (IR64: grey bars) rice transplanted at low (LD) and high (HD) densities under varying nitrogen fertilizer treatments. Nitrogen was applied at 0 Kg ha^{-1} (open bars), 60 Kg ha^{-1} (hatched bars) and 150 Kg ha^{-1} (densely hatched bars). Factors that significantly affected herbivore parameters are presented with significance levels as ** = $p \leq 0.01$ and *** = $p \leq 0.005$. Sampling was conducted during the dry (**A,C,E**) and wet (**B,D,F**) seasons using blow-vac samplers. Standard errors are indicated ($N = 6$).

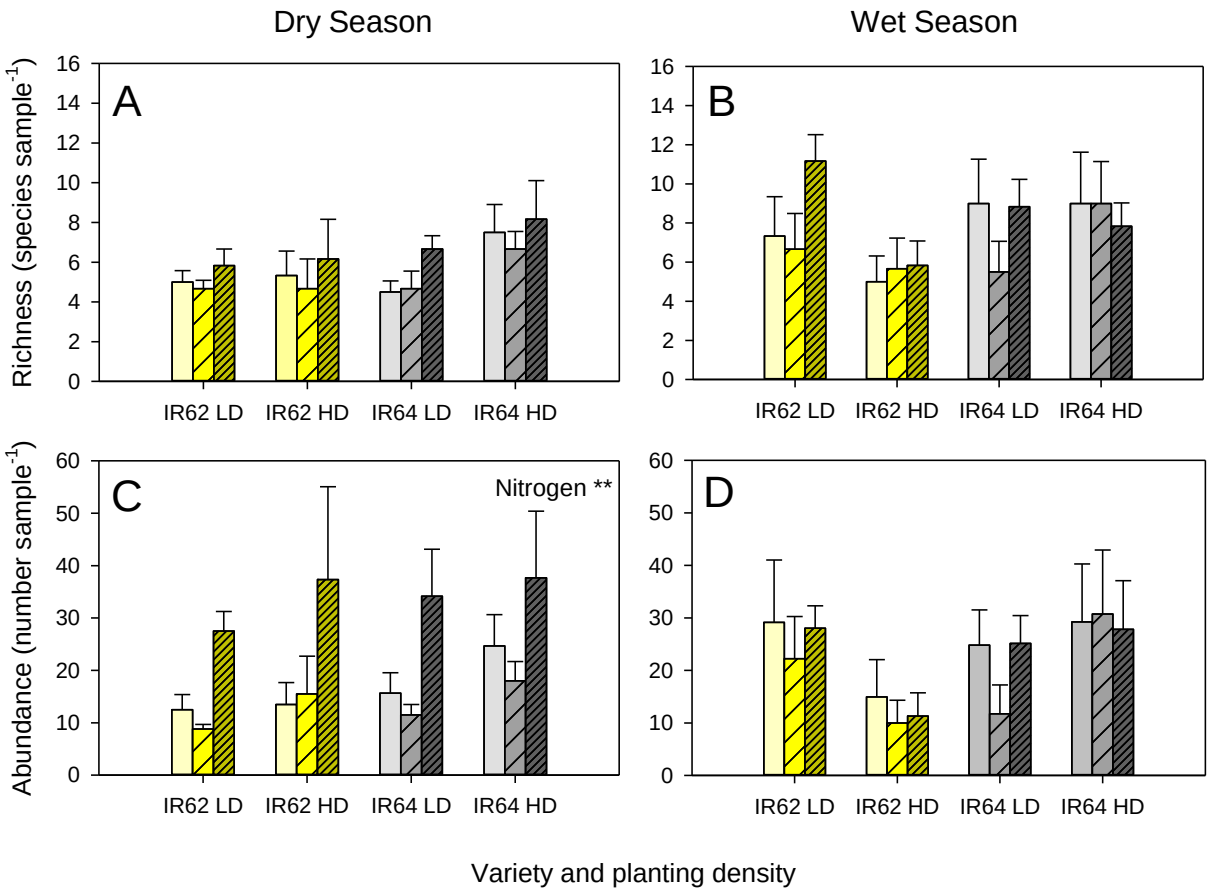

Figure S2. Species richness (**A,B**) and abundance (**C,D**) of decomposers (all species combined) in rice plots with resistant (IR62: yellow bars) and susceptible (IR64: grey bars) rice transplanted at low (LD) and high (HD) densities under varying nitrogen fertilizer treatments. Nitrogen was applied at 0 Kg ha^{-1} (open bars), 60 Kg ha^{-1} (hatched bars) and 150 Kg ha^{-1} (densely-hatched bars). Factors that significantly affected decomposer parameters are presented with significance levels as ** = $p \leq 0.01$. Sampling was conducted during the dry (**A,C**) and wet (**B,D**) seasons using blowvac samplers. Standard errors are indicated ($N = 6$).

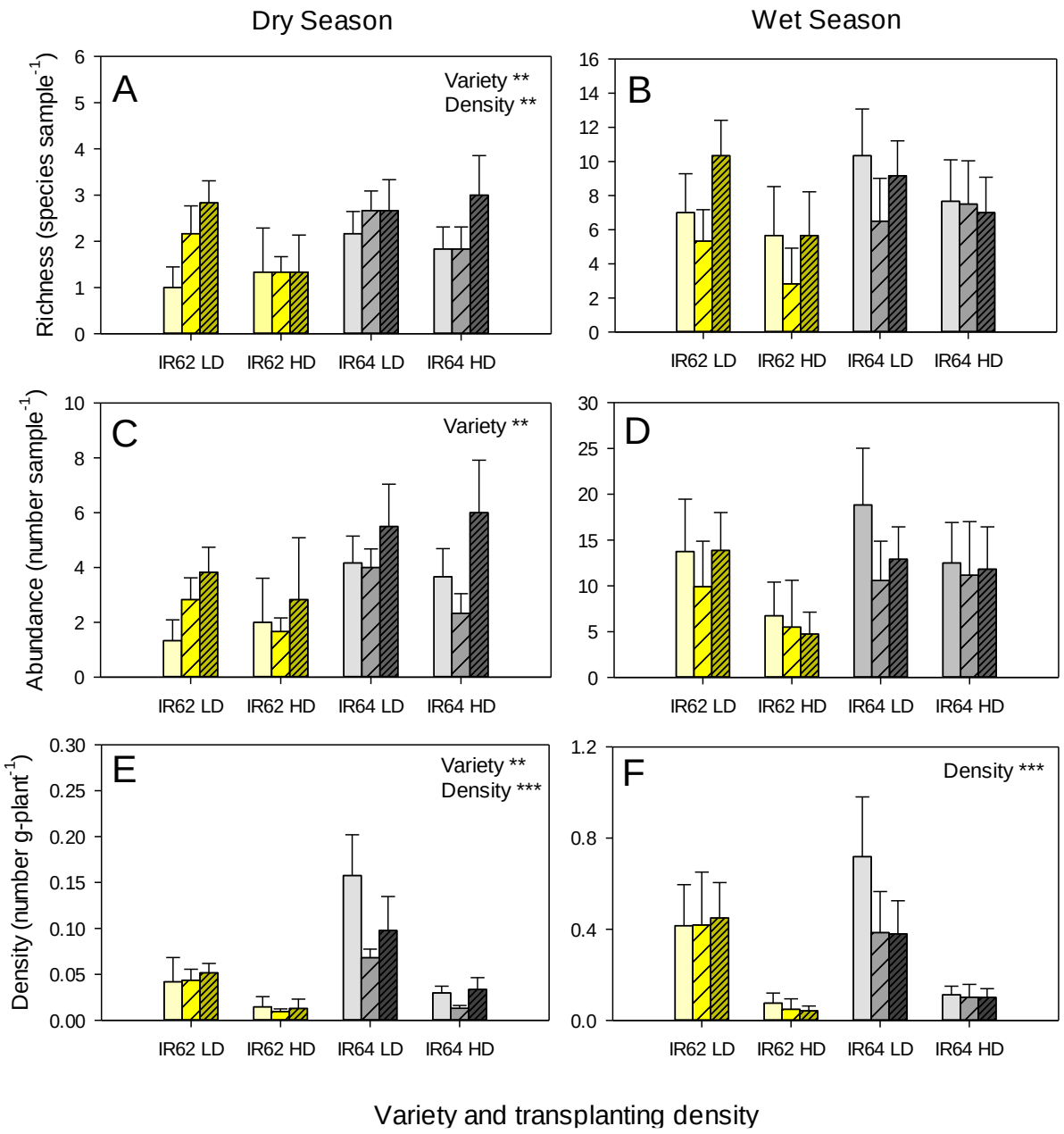

Figure S3. Species richness (**A,B**), abundance (**C,D**) and density (**E,F**) of free-living parasitoids in rice plots with resistant (IR62: yellow bars) and susceptible (IR64: grey bars) rice transplanted at low (LD) and high (HD) densities under varying nitrogen fertilizer treatments. Nitrogen was applied at 0 Kg ha^{-1} (open bars), 60 Kg ha^{-1} (hatched bars) and 150 Kg ha^{-1} (densely-hatched bars). Factors that significantly affected parasitoid parameters are presented with significance levels as ** = $p \leq 0.01$ and *** = $p \leq 0.005$. Sampling was conducted during the dry (**A,C,E**) and wet (**B,D,F**) seasons using blow-vac samplers. Standard errors are indicated ($N = 6$).

Table S2. Abundant rice herbivores (other than planthoppers and leafhoppers) and natural enemies captured during blow-vac sampling in the dry and wet seasons according to subplot variety, transplanting density and nitrogen levels.

Variety[1]	**IR62**	**IR62**	**IR62**	**IR64**	**IR64**	**IR64**	**IR62**	**IR62**	**IR62**	**IR64**	**IR64**	**IR64**
Density[2]	**HD**	**HD**	**HD**	**HD**	**HD**	**HD**	**LD**	**LD**	**LD**	**LD**	**LD**	**LD**
Nitrogen[3]	**0**	**60**	**150**	**0**	**60**	**150**	**0**	**60**	**150**	**0**	**60**	**150**
Dry Season												
Herbivores												
Hydrellia philippina	2	1	1		6	2			3		2	2
Aphididae	18	3	26	29	17	15	24	3	28	32	11	16
Stenchaetothrips bifrmis	9	10	7	10	40	13	7	15	18	8	34	18
Aleurocybotus sp	1	6	5	3	6	10		3	1	3	5	4
Natural enemies												
Trichomalopsis apanteloctena	1	1	1	2	1	10		1	3	1		4
Telenomus dignus		2			1	1	1	1	1			1
Telenomus rowani										2		
Tetrastichus sp.	1		2	1	1		3	5	4	7	8	7
Trichogramma japonicum	1									1	1	
Anagrus flaveolus						2				1	1	1
Anagrus optabilis						1	1	1	1	1		
Gonatucerus sp.	5	3	8	14	9	13	2	7	7	12	8	12
Oligosita aesopi	2	3	3	4	1	4		2	5		4	5
Solenopsis geminata					2							
Microcanthia ornatula	3	2	5	8	3	7	3	3		4		2
Cyrtorhinus lividipennis		2			1	9						1
Micraspis crocea	1	4	2	3	15	9		3	4	1	4	1
Mesoveliidae	8	6	5	4	1	3	9	3	2	1	0	3
Mesovelia vittigera	11	13	20	13	28	30	3	5	4	6	15	13
Microvelia douglasi atrolineata	14	20	22	15	22	32	10	10	0	6	9	11
Micronecta sp.	46	4	90	5	4	46	14	1		15	1	22
Araneus inustus						1		1				
Salticidae (adult)			3			1				1	1	3
Atypena formosana	5	2	3	7	5	6	5	2	2	5	3	7
Pardosa psuedoannulata	8	5	5	10	9	10	13	3	6	19	10	8
Dyschiriognatha sp	2			5	3	8		1		4	5	7
Tetragnatha mandibulata	1		3			2			2		1	3
Tetragnatha javana		1	1	2		1					2	1
Tetragnatha maxillosa	7	5	2	9	11	3	8	4	1	11	3	1
Tetragnatha viriscens	18	53	12	35	36	11	29	34	11	22	17	6
Wet Season												
Herbivores												
Rivula atimeta	1			2	3	1	2	2	4	4	3	1
Naranga aenescens	1	2	1	2	2	4	3	2	3	2		3
Parnara guttata												1
Pyralidae (larva)												1

Marasmia patnalis						1				1		
Papilionidae (larva)			1		1		1		2	1	1	3
Cnaphalocrosis medinalis	1		1	1	3	4				2		
Chilo suppressalis	4						1	2	1	1	1	
Scirpophaga incertulas			1	1	2			1		1		
Agromyza oryzae			3	5	5	3	2	3	10	5	3	5
Anthomiyiidae	1	2	2	8	7	4	5	1	4	4	2	6
Chlorops sp.	7	2	6	6	12	3	8	9	5	13	8	10
Hydrellia griseola	1	3		1	1	1	1	1	1	1		
Hydrellia philippina	9	4	3	10	8	14	6	10	7	4	14	11
Aphididae			2	8		2	2	1		1	1	3
Stenchaetothrips bifrmis	32	24	17	50	38	19	34	21	32	71	37	42
Aleurocybotus sp.	21	5	15	67	104	108	66	37	67	72	15	45
Natural enemies												
Trichomalopsis apanteloctena	1			3	3	2	1	1	1	2	1	
Telenomus sp.	3	1	2				3	3	4	1	1	4
Telenomus dignus			1	3	4	2	2	3	2	7	3	3
Telenomus rowani	2	1	3	2	3	3	4	3	5	2	4	6
Tetrastichus sp.	4	3	3	1	2	2	2	2	2	2	1	1
Trichogramma japonicum	1		2	9	11	7	16	8	12	14	9	7
Anagrus flaveolus	1				2	2	1	1	1	7	3	2
Anagrus optabilis		1		4	3	4	1	1	2	3	3	2
Gonatucerus sp.	10	12	5	9	10	8	15	18	19	13	7	13
Oligosita aesopi	5	8	6	27	17	25	26	9	17	38	17	19
Solenopsis geminata	5	1	2	8	2	2	10	1	2	4	3	3
Microcanthia ornatula												
Cyrtorhinus lividipennis		1	2	6	7	5	4	3	1	3	2	1
Micraspis crocea	2		3	7	4	10	3	2	3	5	4	8
Mesoveliidae	1		1		1							
Mesovelia vittigera	1		2		1		1	1		1	3	1
Microvelia douglasi atrolineata			4		4	5	2	4		8	2	2
Micronecta sp.							2				1	
Araneus inustus	5		5	4	2	8	1	7	7	3	10	3
Salticidae (adult)	1	2		7	10	3	3	2	13	6	1	5
Atypena formosana			2		1	1	2	1	1	2	2	
Pardosa psuedoannulata	5	8	7	8	7	5	8	6	2	7	11	6
Dyschiriognatha sp.	2	2	1	1	1	1	1				1	
Tetragnatha mandibulata	4		1	2	1	3	3	1	7	1	1	1
Tetragnatha javana	2	2	2	10	7	9	4	8	10	4	4	12
Tetragnatha maxillosa	11	12	6	16	13	11	14	6	16	15	15	19
Tetragnatha viriscens	25	38	12	33	21	28	21	11	41	25	29	27

[1]: IR62 is resistant to planthoppers and leafhoppers; [2]: HD = high density planting (10 × 10cm), LD = low-density planting; [3]: 0 = 0 N added, 60 = 60 Kg N added ha^{-1}, 150 = 150 Kg N added ha^{-1}

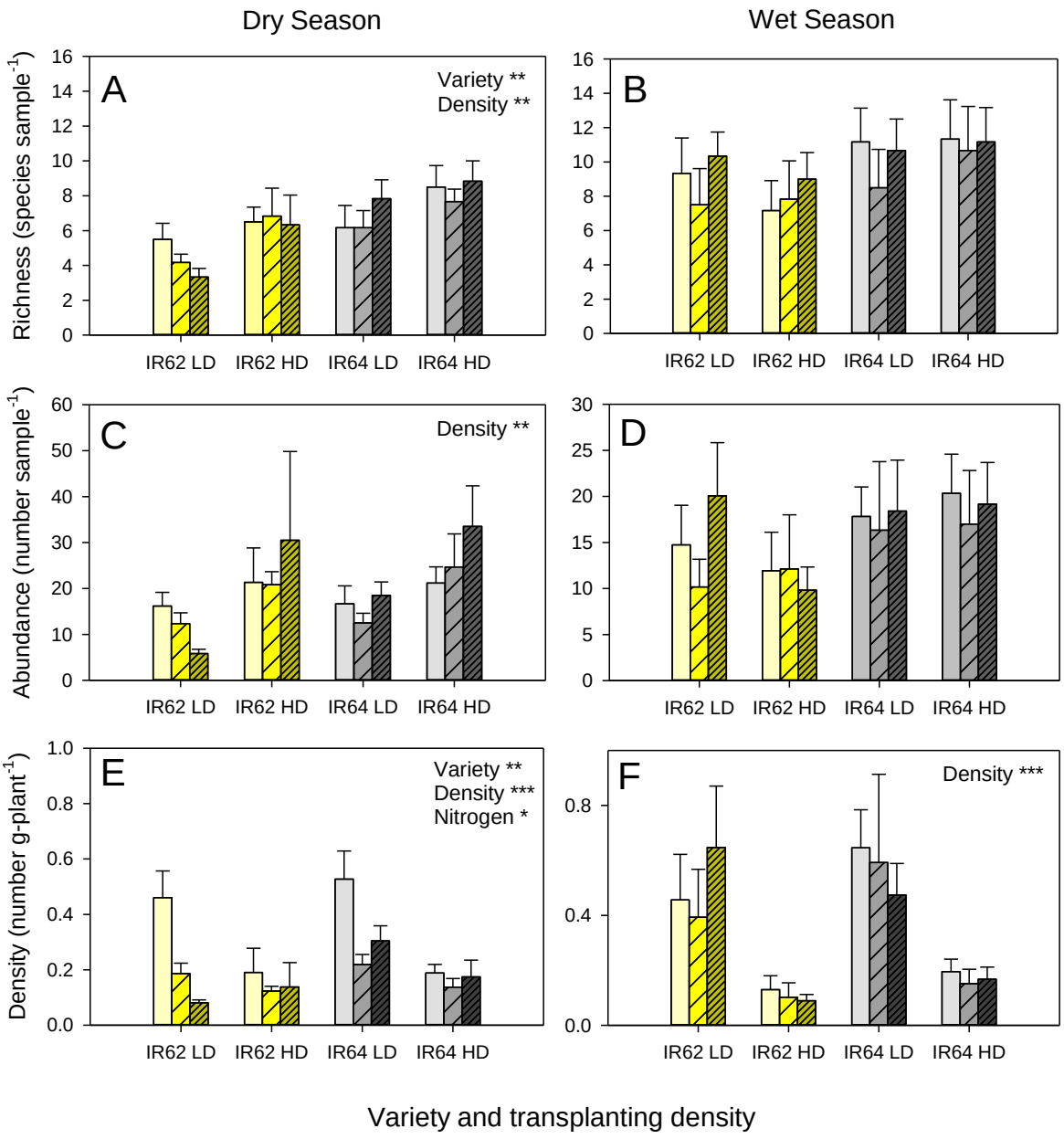

Figure S4. Species richness (**A,B**), abundance (**C,D**) and density (**E,F**) of all predators (excluding parasitoids) in rice plots with resistant (IR62: yellow bars) and susceptible (IR64: grey bars) rice transplanted at low (LD) and high (HD) densities under varying nitrogen fertilizer treatments. Nitrogen was applied at 0 Kg ha^{-1} (open bars), 60 Kg ha^{-1} (hatched bars) and 150 Kg ha^{-1} (densely-hatched bars). Factors that significantly affected predator parameters are presented with significance levels as * = $p \leq 0.05$, ** = $p \leq 0.01$ and *** = $p \leq 0.005$. Sampling was conducted during the dry (**A,C,E**) and wet (**B,D,F**) seasons using blow-vac samplers. Standard errors are indicated ($N = 6$).

Notes on predators

During the DS, more predator species occurred in the IR64 plots ($F_{1,71} = 9.20$, $p = 0.008$) and at high transplanting density ($F_{1,71} = 7.99$, $p = 0.013$) (Figure S4). Predators were more abundant in the high-density plots ($F_{1,71} = 7.92$, $p = 0.013$), largely due to higher numbers of predatory Microvellidae and Mesovellidae bugs (LD = 18.33±3.17, HD = 44.50±5.12: $F_{1,55} = 14.220$, $p < 0.001$); however, this translated to lower predator densities in the same high-density rice stands ($F_{1,71} = 12.70$, $p = 0.003$) because of the higher biomass of plants per unit area. Predator densities were lower in the IR64 plots ($F_{1,71} = 7.50$, $p = 0.015$) and where nitrogen had been added (i.e., 60 and 150 Kg N ha^{-1}: $F_{2,71} = 5.43$, $p = 0.025$) (Figure S4). Variety and nitrogen did not significantly affect species richness or abundance during the WS sampling, but predator densities were lower in the high-density rice stands ($F_{1,71} = 27.52$, $p < 0.001$) (Figure S4).

Table S3. Rice plant condition at harvest during the 2013 dry and wet seasons (see also Figure 9). Numbers and means ± SEM.

Variety	Density [1]	Nitrogen (Kg ha^{-1})	Tiller Number[3]	Root Weight (g plant^{-1})[2,3]	Shoot Weight (g plant^{-1})[2,3]	Plant Height (cm)[3]	Number of Filled Grain3	Weight of 100 Filled Grain (g)	Proportion of Grain Unfilled	Weight of Filled Grains (g plant^{-1})[2,3]	Root:Shoot Ratio[3]
Dry Season											
IR62	LD	0	11.84±0.70 ^{a}	1.81±0.02	18.20±0.27 ^{a}	73.32±0.78 ^{a}	682.06±26.06 ^{a}	2.09±0.02	0.00±0.00	14.11±0.53 ^{a}	0.05±0.00 ^{a}
	LD	60	15.79±0.99 ^{b}	2.13±0.10	21.47±0.99 ^{b}	81.62±0.50 ^{b}	830.75±52.85 ^{ab}	1.98±0.01	0.00±0.00	16.37±1.01 ^{b}	0.06±0.00 ^{a}
	LD	150	18.78±0.61 ^{c}	2.10±0.07	24.91±0.79 ^{c}	86.58±0.69 ^{c}	1018.63±38.41 ^{b}	2.04±0.01	0.00±0.00	20.57±0.69 ^{c}	0.04±0.00 ^{b}
	HD	0	8.06±0.86 ^{a}	1.15±0.03	10.74±0.24 ^{a}	71.29±0.34 ^{a}	326.11±8.62 ^{a}	2.05±0.01	0.01±0.00	6.66±0.15 ^{a}	0.06±0.00 ^{a}
	HD	60	8.95±0.41 ^{b}	1.40±0.04	13.94±0.37 ^{b}	75.58±0.55 ^{b}	385.02±4.57 ^{ab}	2.08±0.02	0.01±0.00	8.02±0.11 ^{b}	0.06±0.00 ^{a}
	HD	150	10.43±0.76 ^{c}	1.49±0.07	17.60±0.78 ^{c}	81.48±0.47 ^{c}	533.06±20.51 ^{b}	2.25±0.01	0.00±0.00	11.99±0.47 ^{c}	0.05±0.00 ^{b}
IR64	LD	0	13.28±0.03 ^{a}	2.01±0.07	18.55±0.63 ^{a}	71.97±0.40 ^{a}	563.68±24.63 ^{a}	2.18±0.02	0.01±0.00	12.33±0.58 ^{a}	0.06±0.00 ^{a}
	LD	60	15.54±0.04 ^{b}	2.46±0.09	24.44±0.88 ^{b}	80.05±0.17 ^{b}	775.29±28.51 ^{ab}	2.31±0.01	0.00±0.00	17.84±0.61 ^{b}	0.06±0.00 ^{a}
	LD	150	18.28±0.74 ^{c}	2.17±0.07	25.44±0.87 ^{c}	87.48±0.68 ^{c}	832.75±33.96 ^{b}	2.32±0.02	0.00±0.00	19.14±0.74 ^{c}	0.05±0.00 ^{b}
	HD	0	6.32±0.53 ^{a}	1.30±0.04	11.98±0.34 ^{a}	71.26±0.75 ^{a}	315.15±17.10 ^{a}	2.29±0.01	0.01±0.00	7.16±0.36 ^{a}	0.06±0.00 ^{a}
	HD	60	8.34±0.47 ^{b}	1.45±0.03	14.39±0.28 ^{b}	79.12±0.33 ^{b}	382.31±8.22 ^{ab}	2.40±0.02	0.01±0.00	9.17±0.21 ^{b}	0.06±0.00 ^{a}
	HD	150	10.03±0.39 ^{c}	1.78±0.05	20.70±0.59 ^{c}	86.28±0.55 ^{c}	555.09±22.44 ^{b}	2.44±0.03	0.01±0.00	13.35±0.47 ^{c}	0.05±0.00 ^{b}
F-variety (1,71)[4]			0.38	2.55	2.09	0.079	1.08	46.38***	0.57	0.16	2.00
F-density (1,71)[4]			119.12***	36.55***	40.08***	5.15*	42.68***	7.70**	5.71*	51.06***	2.00
F-nitrogen (2,71)[4]			18.81**	3.27	13.77***	43.92***	7.30**	3.12	0.29	13.58***	20.00***
Wet Season											
IR62	LD	0	12.77±0.23 ^{a}	4.19±0.21	27.29±1.25 ^{a}	83.22±2.39 ^{a}	865.81±23.49 ^{a}	2.26±0.01	0.00±0.02	19.68±0.63 ^{a}	0.08±0.00 ^{a}
	LD	60	12.95±0.14 ^{b}	3.35±0.07	36.49±1.02 ^{b}	93.28±2.89 ^{a}	1049.15±25.60 ^{b}	2.24±0.02	0.00±0.03	23.49±0.60 ^{b}	0.05±0.00 ^{b}
	LD	150	16.04±0.14 ^{b}	3.90±0.21	44.12±1.45 ^{b}	100.72±2.49 ^{b}	1321.52±56.85 ^{b}	2.16±0.02	0.00±0.04	28.80±1.35 ^{c}	0.05±0.00 ^{b}
	HD	0	7.98±0.12 ^{a}	2.36±0.13	15.86±0.71 ^{a}	86.58±4.39 ^{a}	477.28±19.27 ^{a}	2.29±0.02	0.00±0.00	11.08±0.53 ^{a}	0.08±0.00 ^{a}
	HD	60	8.63±0.26 ^{b}	1.91±0.07	22.26±0.48 ^{b}	95.14±5.53 ^{a}	572.04±22.30 ^{b}	2.27±0.02	0.00±0.00	12.90±0.49 ^{b}	0.05±0.00 ^{b}
	HD	150	8.79±0.36 ^{b}	2.45±0.12	19.91±0.57 ^{b}	99.64±2.34 ^{b}	585.19±21.68 ^{b}	2.33±0.01	0.00±0.01	13.67±0.52 ^{c}	0.07±0.00 ^{b}
IR64	LD	0	12.53±0.22 ^{a}	4.26±0.18	26.28±1.02 ^{a}	78.69±1.76 ^{a}	821.29±23.97 ^{a}	2.41±0.01	0.00±0.08	19.84±0.63 ^{a}	0.09±0.00 ^{a}
	LD	60	11.92±0.26 ^{b}	4.26±0.26	35.67±1.27 ^{b}	89.31±2.53 ^{a}	1059.73±54.91 ^{b}	2.44±0.02	0.00±0.09	25.57±1.25 ^{b}	0.07±0.00 ^{b}
	LD	150	17.00±0.26 ^{b}	4.97±0.26	41.36±1.21 ^{b}	87.94±5.43 ^{b}	1137.21±48.95 ^{b}	2.43±0.01	0.00±0.10	27.60±1.18 ^{c}	0.07±0.00 ^{b}
	HD	0	8.69±0.40 ^{a}	2.50±0.24	13.64±0.87 ^{a}	87.00±2.06 ^{a}	360.63±27.44 ^{a}	2.41±0.01	0.00±0.05	8.68±0.67 ^{a}	0.11±0.00 ^{a}

HD	60	9.21±0.24 [b]	2.29±0.06	20.36±0.48 [b]	93.31±1.11 [a]	508.84±30.20 [b]	2.41±0.02	0.00±0.06	12.24±0.73 [b]	0.07±0.00 [b]
HD	150	9.08±0.13 [b]	2.69±0.14	22.41±0.80 [b]	94.39±1.18 [b]	520.04±17.42 [b]	2.41±0.01	0.00±0.07	12.59±0.45 [c]	0.08±0.00 [b]
F-variety (1,71)[4]		1.12	1.08	0.13	5.08*	1.62	21.18***	2.40	0.98	3.40
F-density (1,71)[4]		113.49***	29.22***	76.22***	3.41	78.59***	0.74	0.40	75.26***	0.85
F-nitrogen (2,71)[4]		14.53***	0.73	12.40***	11.79***	6.25**	0.02	0.00	5.84*	5.53*

[1]: LD = low density, HD = high density; [2]: All weights are presented as dry weights; [3]: Lower case letters indicate homogenous nitrogen groups based on Tukey pairwise comparisons (P > 0.05); [4]: F-values are based on GLMs for a split-split plot design; numbers in parentheses are degrees of freedom; * = $p \leq 0.05$, ** = $p \leq 0.01$, *** = $p \leq 005$; interaction terms were not significant