

Supplementary materials

Intercropping of rice and water mimosa (*Neptunia oleracea* Lour.): a novel model to control pests and diseases and improve yield and grain quality while reducing N fertilizer application

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Table S1. Incidence (%) of rice leaf blast in monocropping and intercropping treatments with the three different N fertilizer application levels.

Season	N fertilizer	Pattern	Day					
			50th	55th	60th	65th	70th	75th
2018 late season	ZN	Mono	23.59±3.80Aa	27.13±1.07Aa	36.75±3.55Aa	38.80±2.23Aa	39.58±3.06Aa	40.40±2.48Aa
		Inter	25.89±4.35Aa	24.14±2.33Aa	26.23±1.81Ba	28.98±2.84Ba*	28.27±2.44Aa	32.68±5.20Aa
	RN	Mono	24.54±2.92Aa	26.57±1.30Aa	36.60±3.67Aa	38.02±4.60Aa	44.10±2.61Aa	45.43±2.27Aa
		Inter	18.54±2.75Aa	22.57±1.36Ba	27.35±2.22Ba	24.74±2.09Ba*	23.69±2.13Ba*	34.12±0.68Ba
	CN	Mono	17.55±4.09Aa	22.38±1.81Aa	30.11±4.79Aa	35.05±3.80Aa*	33.64±2.34Aa*	38.97±2.61Aa
		Inter	16.92±1.33Aa	21.75±0.91Aa	26.12±1.71Aa	24.59±1.91Ba	25.18±2.16Ba	30.81±2.43Ba
2019 early season	ZN	Mono	25.97±2.91Aa	28.19±2.59Aa	34.36±0.70Aa	33.63±1.90Aa	28.28±1.70Aa	34.59±1.63Aa
		Inter	20.63±2.34Aa	22.22±1.02Aa*	26.75±2.17Ba*	24.32±2.36Aa*	25.97±2.74Aa	25.22±3.96Aa
	RN	Mono	27.82±1.52Aa	28.92±2.39Aa	32.99±0.97Aa	33.76±1.13Aa	28.95±0.94Aa	36.01±1.21Aa
		Inter	20.55±2.23Ba	24.26±1.03Aa*	23.23±1.16Ba*	21.78±0.65Ba*	21.63±0.91Ba	23.63±1.04Ba*
	CN	Mono	38.33±13.45Aa	32.98±1.38Aa*	32.70±1.00Aa*	31.45±1.72Aa*	23.50±1.80Aa	33.32±0.50Aa*
		Inter	19.84±1.22Aa	23.51±1.09Ba	21.92±1.14Ba	21.11±0.84Ba	20.63±0.87Aa	21.69±1.89Ba

All the data presented are the means of four replicates \pm standard errors. Different capital letters indicate significant differences between cultivation patterns under the same N fertilizer level ($P < 0.05$). Different small letters indicate significant differences between N fertilizer levels in the same cultivation pattern ($P < 0.05$). ZN, RN and CN indicate the 0, 140 and 180 kg ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments. The “*” represents the significant difference between monocropping with the conventional N treatments and intercropping with zero and reduced N treatments ($P < 0.05$).

Table S2. Variance in incidence of rice leaf blast between the 2018 late season and 2019 early season.

N fertilizer	Pattern	50th	55th	60th	65th	70th	75th
CK	Mono	ns	ns	ns	ns	ns	ns
	Inter	ns	ns	ns	ns	ns	ns
RN	Mono	ns	ns	ns	ns	V(2018) > V(2019)	V(2018) > V(2019)
	Inter	ns	ns	ns	ns	ns	ns
CN	Mono	ns	V(2018) < V(2019)	ns	ns	ns	V(2018) > V(2019)
	Inter	ns	ns	ns	ns	ns	V(2018) > V(2019)

V(2018) and V(2019) denote the mean value of these indexes. “>” and “<” represent the significant differences between the index in the 2018 late season and 2019 early season. “ns” indicate no significant difference. ZN, RN and CN indicate the 0, 140 and 180 kg·ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments.

Table S3. Incidence (%) of rice leaf folders in monocropping and intercropping treatments with the three different N fertilizer application levels.

Season	N fertilizer	Pattern	Day					
			50th	55th	60th	65th	70th	75th
2018 late season	ZN	Mono	11.30±2.64Aa	11.99±2.62Aa	19.48±3.88Aa	22.59±3.22Aa	31.90±3.72Aa	32.80±2.63Aa
		Inter	6.53±0.99Aa	11.46±0.89Aa*	13.61±1.28Aa	14.58±0.87Aa*	18.22±1.58Ba	26.26±2.59Aa
	RN	Mono	9.15±0.89Aa	13.058±1.77Aa	23.90±1.54Aa	24.73±3.11Aa	32.72±1.67Aa	39.79±2.39Aa
		Inter	6.54±0.60Aa	11.83±0.77Aa	14.26±1.16Ba	14.23±0.58Ba*	18.79±2.09Ba	25.96±0.87Ba
	CN	Mono	7.46±1.63Aa	14.22±0.42Aa*	20.61±3.36Aa	25.66±0.91Aa*	25.74±3.69Aa	32.81±3.44Aa
		Inter	5.84±0.32Aa	12.07±1.91Aa	14.80±1.20Aa	14.53±1.74Ba	19.07±2.41Aa	24.19±2.50Ba
2019 early season	ZN	Mono	20.57±2.67Aa	22.65±2.57Aa	24.16±1.28Aa	31.79±2.98Aa	25.51±1.44Aa	30.26±1.43Aa
		Inter	18.54±1.97Aa	15.60±1.11Aa*	20.78±2.73Aa	20.31±2.60Aa*	24.53±3.16Aa	21.25±3.29Ba
	RN	Mono	22.50±1.54Aa	22.59±2.14Aa	25.20±1.63Aa	29.82±1.47Aa	26.90±1.73Aa	32.49±1.56Aa
		Inter	16.49±1.75Ba	16.12±1.36Aa*	17.12±1.92Ba*	18.62±0.81Ba*	20.09±0.49Ba	20.78±1.35Ba*
	CN	Mono	23.64±3.72Aa	24.95±1.00Aa*	24.81±1.38Aa*	26.73±1.31Aa*	26.84±5.92Aa	27.98±0.92Aa*
		Inter	14.65±1.31Aa	16.53±0.88Ba	17.59±0.65Ba	15.97±0.13Ba	18.32±0.52Aa	18.66±1.57Aa

All the data presented are the means of four replicates \pm standard errors. Different capital letters indicate significant differences between cultivation patterns under the same N fertilizer level ($P < 0.05$). Different small letters indicate significant differences between N fertilizer levels in the same cultivation pattern ($P < 0.05$). ZN, RN and CN indicate the 0, 140 and 180 kg ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments. The “*” represents the significant difference between monocropping with the conventional N treatments and intercropping with zero and reduced N treatments ($P < 0.05$).

Table S4. Variance in incidence of rice leaf folders between the 2018 late season and 2019 early season.

N fertilizer	Pattern	50th	55th	60th	65th	70th	75th
CK	Mono	ns	V(2018) < V(2019)	ns		ns	ns
	Inter	V(2018) < V(2019)	ns	ns	V(2018) < V(2019)	ns	ns
RN	Mono	V(2018) < V(2019)	V(2018) < V(2019)	ns		V(2018) > V(2019)	V(2018) > V(2019)
	Inter	V(2018) < V(2019)	ns	ns	V(2018) < V(2019)	ns	ns
CN	Mono	V(2018) < V(2019)	V(2018) < V(2019)	ns	ns	ns	ns
	Inter	V(2018) < V(2019)	ns	ns	ns	ns	V(2018) > V(2019)

V(2018) and V(2019) denote the mean value of these indexes. “>” and “<” represent the significant differences between the index in the 2018 late season and 2019 early season. “ns” indicate no significant difference. ZN, RN and CN indicate the 0, 140 and 180 kg·ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments.

Table S5. Disease index (%) of rice sheath blight in monocropping and intercropping treatments with the three different N fertilizer application levels.

Season	N fertilizer	Pattern	Day					
			50th	55th	60th	65th	70th	75th
2018 late season	ZN	Mono	24.00±1.22Aa	25.00±4.79Aa	33.33±4.93Aa	29.33±6.13Aa	42.22±1.13Aa	40.67±2.00Aa
		Inter	15.33±1.16Ba	19.34±2.00Aa*	30.67±1.44Aa	25.67±3.54Aa	31.00±2.39Ba	32.67±2.07Ba
	RN	Mono	24.00±3.03Aa	33.34±2.31Aa	38.67±3.03Aa	37.00±5.26Aa	40.33±2.52Aa	42.67±1.44Aa
		Inter	16.67±1.59Aa	22.00±1.15Ba	32.34±1.00Aa	29.00±3.05Aa	28.00±1.96Ba	38.33±2.69Aa
	CN	Mono	17.33±4.25Aa	26.00±2.96Aa*	32.00±5.47Aa	36.00±2.61Aa	32.00±5.42Aa	40.00±4.71Aa
		Inter	16.67±2.28Aa	21.34±3.96Aa	29.67±3.83Aa	23.67±4.85Ba	28.00±4.52Aa	35.00±2.52Aa
2019 early season	ZN	Mono	18.67±3.31Aa	30.22±1.13Aa	24.67±4.41Aa	33.33±1.44Aa	32.00±1.44Aa	32.67±0.86Aa
		Inter	11.33±2.07Aa*	30.00±2.47Aa	20.89±3.19Aa	25.00±1.48Ba*	29.00±1.14Aa	27.33±0.86Ba*
	RN	Mono	27.67±2.74Aa	31.67±1.67Aa	32.00±3.31Aa	36.00±1.96Aa	34.67±1.44Aa	34.33±1.14Aa
		Inter	17.00±2.90Aa*	30.00±1.59Aa	20.67±2.70Ba*	26.33±1.14Ba*	29.00±1.67Aa	26.00±0.86Ba*
	CN	Mono	24.67±1.39Aa*	31.33±0.86Aa	29.90±2.54Aa*	34.67±1.22Aa*	30.67±1.44Aa	32.67±0.86Aa*
		Inter	14.33±1.84Ba	29.00±1.14Aa	17.33±2.88Ba	26.00±1.44Ba	27.00±1.14Aa	27.00±1.14Ba

All the data presented are the means of four replicates ± standard errors. Different capital letters indicate significant differences between cultivation patterns under the same N fertilizer level ($P < 0.05$). Different small letters indicate significant differences between N fertilizer levels in the same cultivation pattern ($P < 0.05$). ZN, RN and CN indicate the 0, 140 and 180 kg ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments. The “*” represents the significant difference between monocropping with the conventional N treatments and intercropping with zero and reduced N treatments ($P < 0.05$).

Table S6. Variance in incidence of rice sheath blight between the 2018 late season and 2019 early season.

N fertilizer	Pattern	50th	55th	60th	65th	70th	75th
CK	Mono	ns	ns	ns	ns	V(2018) > V(2019)	V(2018) > V(2019)
	Inter	ns	V(2018) < V(2019)	ns	ns	ns	ns
RN	Mono	ns	ns	ns	ns	V(2018) > V(2019)	V(2018) > V(2019)
	Inter	ns	V(2018) < V(2019)	V(2018) > V(2019)	ns	ns	V(2018) > V(2019)
CN	Mono	ns	ns	ns	ns	ns	ns
	Inter	ns	ns	ns	ns	ns	V(2018) > V(2019)

V(2018) and V(2019) denote the mean value of these indexes. “>” and “<” represent the significant differences between the index in the 2018 late season and 2019 early season. “ns” indicate no significant difference. ZN, RN and CN indicate the 0, 140 and 180 kg·ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments.

Table S7. Interaction effects between the two factors (cultivation pattern and N fertilizer) on rice yield and yield components by two-way ANOVA.

Season	Index	Pattern	N fertilizer	Pattern * N fertilizer
2018 late season	Yield	60.17**	16.47**	9.23**
	Per unit effective panicle numbers	18.04**	11.64**	4.98*
	Grain number per panicle	1.42	1.13	0.13
	Seed-setting rate	0	0.05	0.43
	1000-grain weight	11.84	1.24	0.01
2019 early season	Yield	42.42**	6.33**	4.24*
	Per unit effective panicle numbers	62.97**	4.29*	5.70*
	Grain number per panicle	1.06	0.12	1.01
	Seed-setting rate	0.17	0.32	0.39
	1000-grain weight	0.21	2.06	0.02

The cultivation pattern and N fertilizer were the two independent factors, and the F-values are presented in the table. “ * ” $P < 0.05$; “ ** ” $P < 0.01$.

Table S8. Variance in rice yield and yield components between the 2018 late season and 2019 early season.

N ferti- zer	Patte- rn	Rice							Wate- r mimo- sa
		Per unit yield	Actual yield	Per unit effective panicle	Actual effective panicle	Grains per panicle	Seed-setting rate	1000-grain weight	Yield
CK	Mon- o	V(2018) <	V(2018) <	ns	ns	V(2018) >	V(2018) <	V(2018) >	ns
		V(2019)	V(2019)			V(2019)	V(2019)	V(2019)	
	Inter	V(2018) <	V(2018) <	V(2018) <	V(2018) <	V(2018) >	V(2018) <	V(2018) >	ns
		V(2019)	V(2019)	V(2019)	V(2019)	V(2019)	V(2019)	V(2019)	
RN	Mon- o	V(2018) <	V(2018) <	V(2018) <	V(2018) <	V(2018) >	V(2018) <	V(2018) >	ns
		V(2019)	V(2019)	V(2019)	V(2019)	V(2019)	V(2019)	V(2019)	
	Inter	V(2018) <	V(2018) <	ns	ns	V(2018) >	V(2018) <	ns	ns
		V(2019)	V(2019)			V(2019)	V(2019)		
CN	Mon- o	V(2018) <	V(2018) <	ns	ns	V(2018) >	V(2018) <	ns	ns
		V(2019)	V(2019)			V(2019)	V(2019)		
	Inter	V(2018) <	V(2018) <	ns	ns	ns	V(2018) <	V(2018) >	ns
		V(2019)	V(2019)				V(2019)	V(2019)	

V(2018) and V(2019) denote the mean value of these indexes. “>” and “<” represent the significant differences between the index in the 2018 late season and 2019 early season. “ns” indicate no significant difference. ZN, RN and CN indicate the 0, 140 and 180 kg·ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments.

Table S9. Interaction effects between the two factors (cultivation pattern and N fertilizer) on rice grain quality determined by two-way ANOVA.

Season	Index	Pattern	N fertilizer	Pattern * N fertilizer
2018 late season	Brown rice rate	1.10	2.00	3.13
	Milled rice rate	0.33	1.09	0.83
	Head rice rate	3.08	1.12	0.08
	Length/width	0.07	0.88	0.20
	Chalky rice rate	31.53**	0.66	0.17
	Chalkiness degree	14.21**	0.67	3.47
	Amylose content	3.82	2.74	0.05
	Protein content	0.54	0.05	0.40
	Alkali value	0.03	18.03**	0.03
	Brown rice rate	0.72	4.42*	0.32
2019 early season	Milled rice rate	0.15	1.09	1.62
	Head rice rate	0.06	0.60	0.85
	Length/width	1.06	7.15**	2.18
	Chalky rice rate	19.58**	0.92	0.57
	Chalkiness degree	11.97**	1.88	1.87
	Amylose content	2.44	2.90	0.23
	Protein content	0.08	21.16**	0.19
	Alkali value	0.03	9.92**	1.22

The cultivation pattern and N fertilizer level were the two independent factors, and the F-values are presented in the table. “ * ” $P < 0.05$; “ ** ” $P < 0.01$.

Table S10. Variance in rice grain quality between the 2018 late season and 2019 early season.

N ferti zer	Patte rn	Brown rice rate	Milled rice rate	Head rice rate	Length/w idth	Chal ky rice rate	Chalkin ess degree	Amylose content	Protein content	alkali
CK	Mon o	V(2018) < V(2019)		V(2018) < V(2019)	ns	ns	ns	ns	V(2018) < V(2019)	ns
	Inter	V(2018) < V(2019)		V(2018) < V(2019)	ns	ns	ns	ns	V(2018) < V(2019)	ns
RN	Mon o	V(2018) < V(2019)	V(2018) < V(2019)	V(2018) < V(2019)	ns	ns	ns	V(2018) < V(2019)	V(2018) < V(2019)	ns
	Inter	V(2018) < V(2019)		V(2018) < V(2019)	ns	ns	ns	ns	V(2018) < V(2019)	V(2018) < V(2019)
CN	Mon o			V(2018) < V(2019)	ns	ns	ns	V(2018) < V(2019)	V(2018) < V(2019)	ns
	Inter	V(2018) < V(2019)	V(2018) < V(2019)	V(2018) < V(2019)	ns	ns	ns	ns	V(2018) < V(2019)	ns

V(2018) and V(2019) denote the mean value of these indexes. “>” and “<” represent the significant differences between the index in the 2018 late season and 2019 early season. “ns” indicate no significant difference. ZN, RN and CN indicate the 0, 140 and 180 kg·ha⁻¹ N fertilizer levels, respectively. “Mono” and “Inter” denote the monocropping and intercropping treatments.

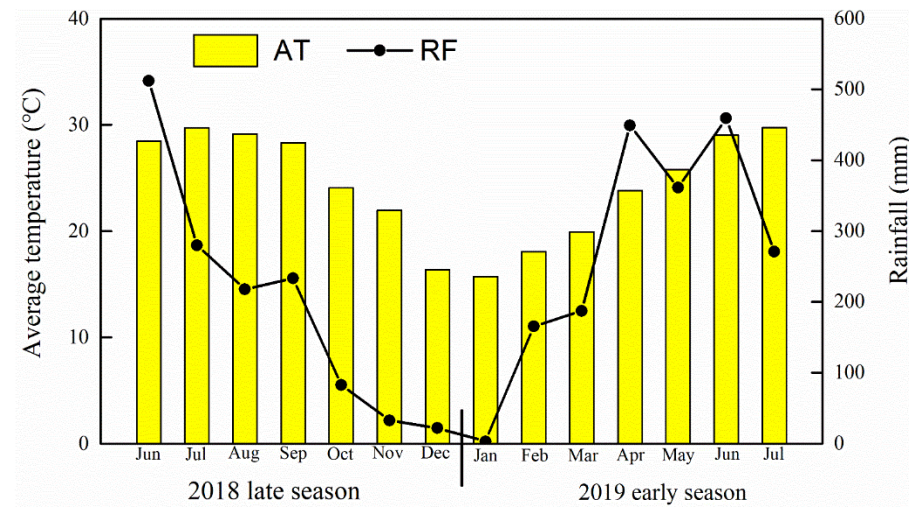


Figure S1. Rainfall (RF) and average temperature (AT) per month during the two seasons in Zengcheng, Guangzhou, Guangdong, China

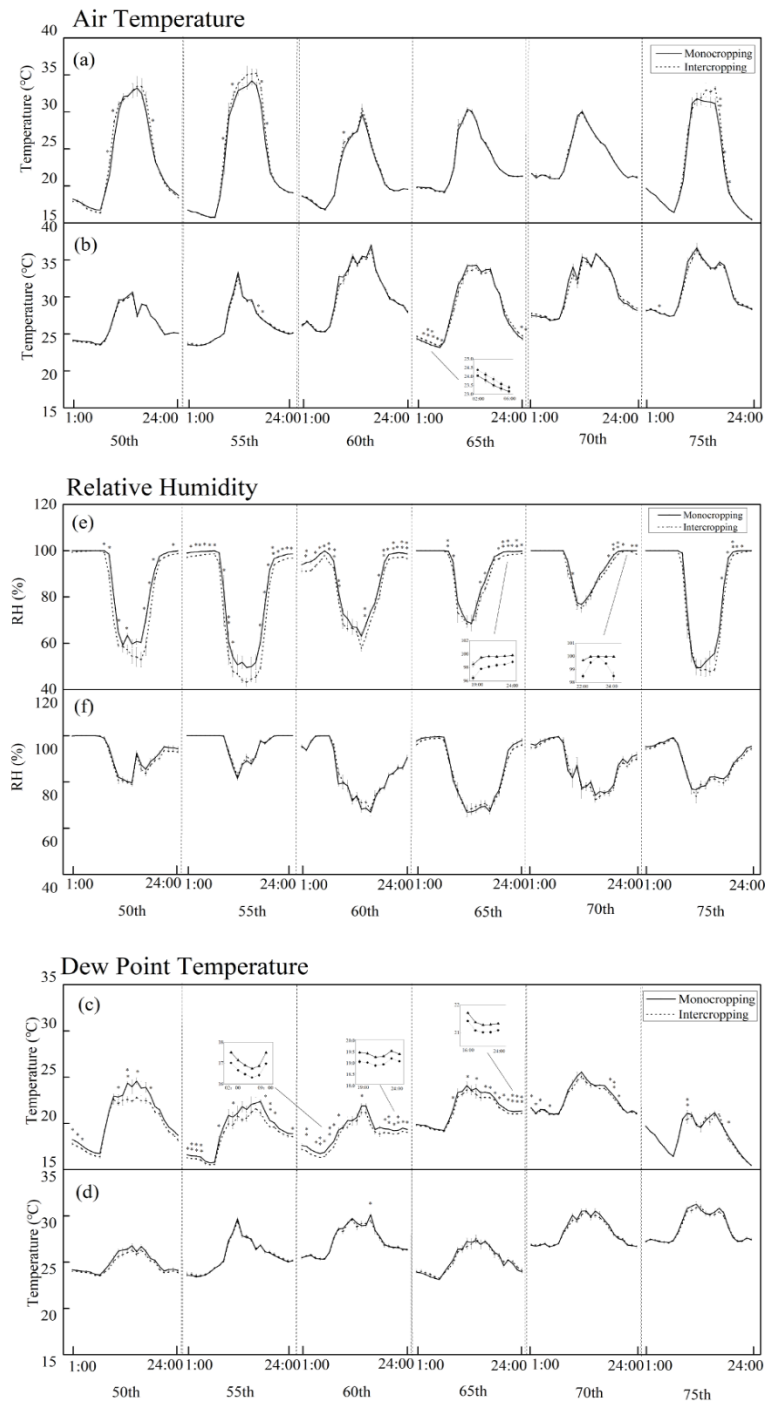
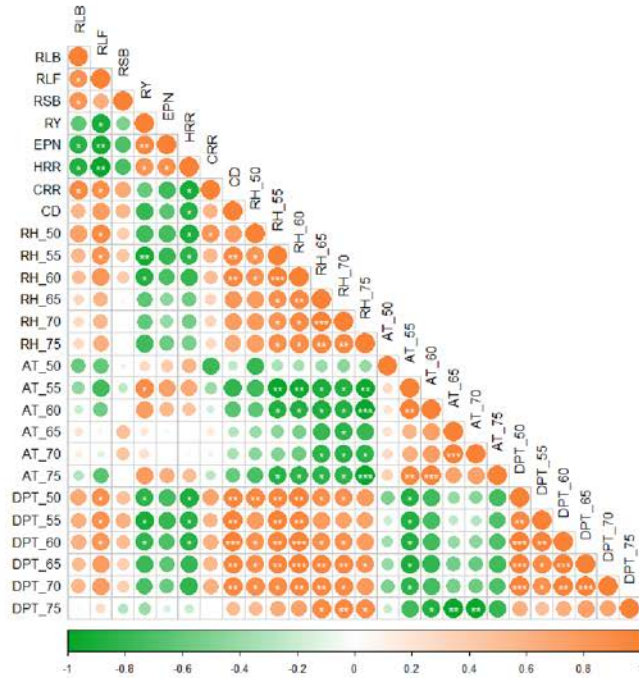


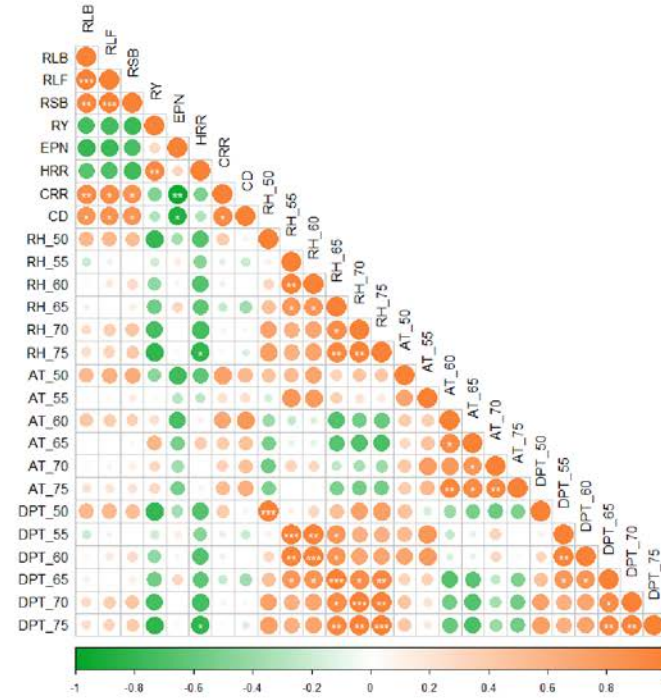
Figure S2. Air temperature, relative humidity (RH) and dew point temperature of rice canopy in the monocropping and intercropping under the reduced N fertilizer application level. All the data presented are the means of three replicates \pm standard errors. And the data were investigated on the 50th, 55th, 60th, 65th, 70th, and 75th days after transplanting.

(a)



2018 late season

(b)



2019 early season

Figure S3. Pearson correlations among daily air temperature (AT), dew point temperature (DPT) and relative humidity (RH) of rice canopy at 50th ~ 75th after transplanting, rice leaf blast (RLB), rice leaf folders (RLF) and rice sheath blight (RSB) at 75th day after transplanting, rice yield (RY), per unit effective panicle number (EPN), head rice rate (HRR), chalky rice rate (CRR) and chalkiness degree (CD) at maturity stage. All the data were under the RN treatment. The “*” represents the significant difference between indexes.