

Supplementary Materials

Using DNDC and WHCNS_Veg to optimize management strategies for improving potato yield and nitrogen use efficiency in northwest China

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Table S1. Soil physical and chemical properties at 0-0.6 layer in the experimental site.

Soil layer (m)	pH	Bulk density (g cm ⁻³)	Field capacity (%)	Saturation (%)	Clay content (%)	Organic carbon (%)	Alkaline -Hydrolysis N (mg kg ⁻¹)	Available P (mg kg ⁻¹)	Available K (mg kg ⁻¹)
0.0-0.2	8.0	1.4	32.3	35.2	18.0	1.9	77.7	21.2	101.0
0.2-0.4	8.4	1.5	27.6	28.7	16.5	-	-	-	-
0.4-0.6	8.5	1.5	23.6	25.5	14.8	-	-	-	-

Table S2. Fertilizer application rate of nitrogen (N), phosphorus (P), and potassium (K) across all the treatments from 2017 to 2020.

Year	Treatment	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	N ratio (%)	P ratio (%)	K ratio (%)
2017	N0	0	66	194	30/40/30	100	100
	N1	90	66	194	30/40/30	100	100
	N2	135	66	194	30/40/30	100	100
	N3	180	66	194	30/40/30	100	100
	N4	270	66	194	30/40/30	100	100
2018	N0	0	79	224	30/40/30	100	50/50
	N1	120	79	224	30/40/30	100	50/50
	N2	180	79	224	30/40/30	100	50/50
	N3	240	79	224	30/40/30	100	50/50
	N4	360	79	224	30/40/30	100	50/50
2019	N0	0	40	198	25/25/50	100	100
	N1	105	40	198	25/25/50	100	100
	N2	157	40	198	25/25/50	100	100
	N3	209	40	198	25/25/50	100	100
	N4	314	40	198	25/25/50	100	100
2020	N0	0	37	111	25/25/50	100	100
	N1	89	37	111	25/25/50	100	100
	N2	134	37	111	25/25/50	100	100
	N3	178	37	111	25/25/50	100	100
	N4	267	37	111	25/25/50	100	100

Table S3. The default and calibrated parameters of the DNDC model for potato at experimental site.

Parameter	Default values				Calibrated parameters			
	Grain	Leaf	Stem	Root	Grain	Leaf	Stem	Root
Max biomass production (kg C ha ⁻¹)	6000	1114	1114	343	4000	857	686	171
Biomass fraction	0.7	0.13	0.13	0.04	0.7	0.15	0.12	0.03
Biomass C/N ratio	60	60	60	60	25.5	20	35	80
Thermal degree days for maturity			2100				2200	
Water demand (g g ⁻¹)			415				370	
Optimum temperature (°C)			25				24	
Field capacity (WFPS)			0.32				0.58	
Wilting point (WFPS)			0.15				0.35	

Table S4. The default and calibrated parameters of the WHCNS_Veg model for potato at experimental site.

Groups	Parameter	Description	Default values	Calibrated parameters
Crop parameters	Kini	Crop coefficient in initial stage (-)	0.9	0.9
	Kmid	Crop coefficient in middle stage (-)	1.15	1.2
	Kend	Crop coefficient in end stage (-)	0.65	0.4
	Tsum	Accumulated temperature (°C)	1300	1400
	α_{DM}	Dry matter accumulation empirical parameter (t ha ⁻¹)	1	1
	δ_y	Standard deviation of the harvested parts (t ha ⁻¹)	0.35	0.3
	Rmax	Maximum root depth (cm)	50	50
Nitrogen transformation parameters	Nmin	The minimum N concentration of plant	2.45	2.05
	Vn	Maximum nitrification rate (g m ⁻³ d ⁻¹)	80	10
	Kn	Nitrification half saturation constant (g m ⁻³)	100	150

Table S5. Potato straw and tuber N content in different treatments across 4-year experiment.

Treatment	Straw N content (%)	Tuber N content (%)
N0	1.69b	1.75c
N1	1.92a	2.01bc
N2	1.93a	2.13ab
N3	1.85a	2.15ab
N4	1.84a	2.35a

Table S6. Statistical analysis of potato tuber yield and plant nitrogen uptake for different treatments across the 4-year experiment.

Year	Treatment	Yield ¹ (t ha ⁻¹)	Plant N uptake (kg ha ⁻¹)
2017	N0	26.2 c	99.2 c
	N1	29.7 b	130.9 bc
	N2	32.2 a	151.4 ab
	N3	32.1 a	165.7 a
	N4	30.8 ab	151.4 ab
2018	N0	36.5 d	161.7 d
	N1	43.0 c	196.2 c
	N2	45.4 bc	230.4 b
	N3	51.1 a	256.5 a
	N4	48.2 ab	264.2 a
2019	N0	29.3 c	141.0 c
	N1	36.8 b	173.4 b
	N2	41.8 a	209.9 a
	N3	42.4 a	234.8 a
	N4	39.4 ab	210.1 a
2020	N0	22.9 b	65.2 b
	N1	24.7 ab	101.2 a
	N2	25.9 ab	106.7 a
	N3	27.3 a	113.5 a
	N4	26.8 a	106.5 a

¹ Values followed by different lowercase letters for different treatments in the same year are significantly different with LSD test at p < 0.05.

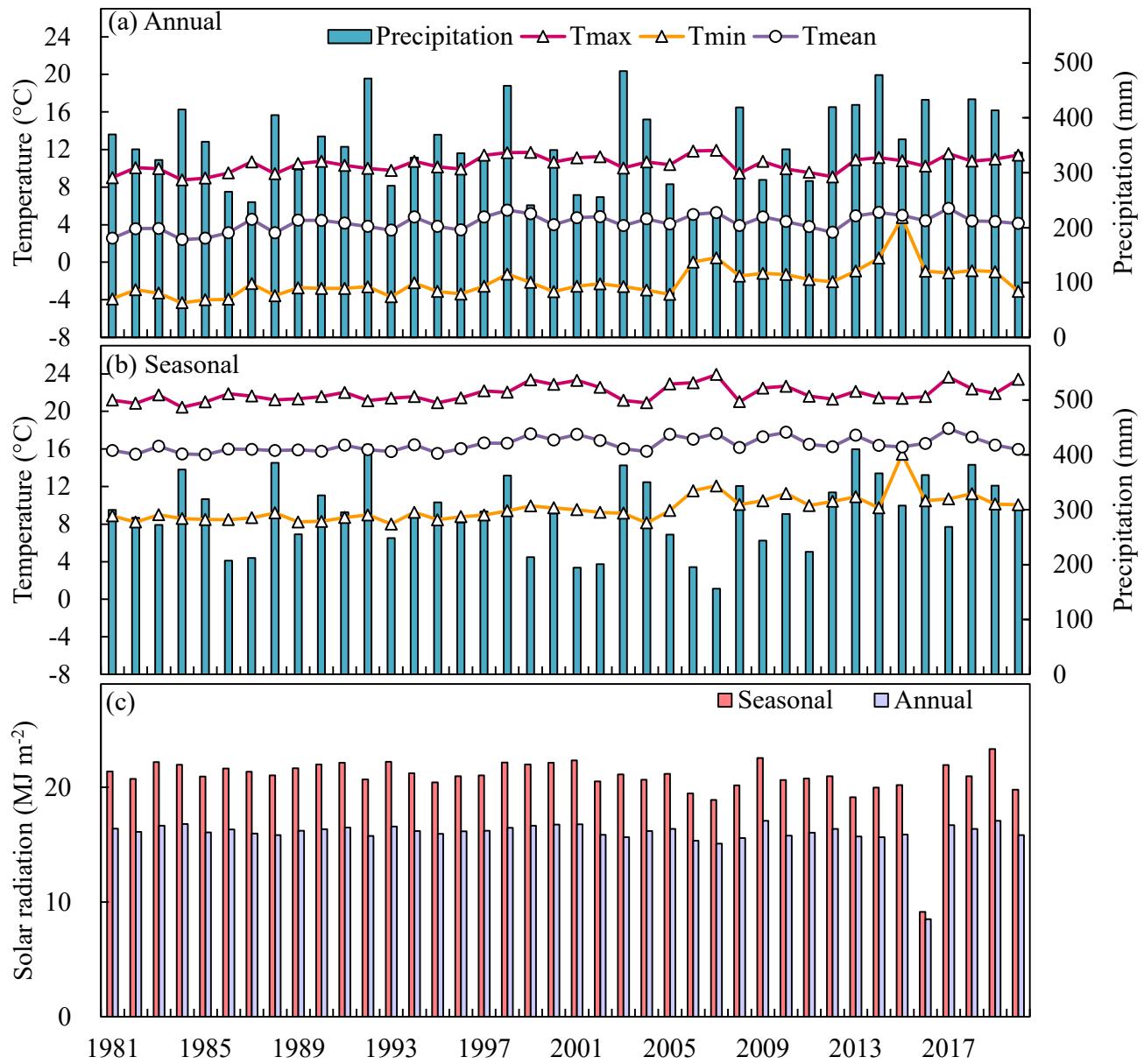


Figure S1. Annual and seasonal average climate conditions of the experimental site across the years from 1981 to 2020.

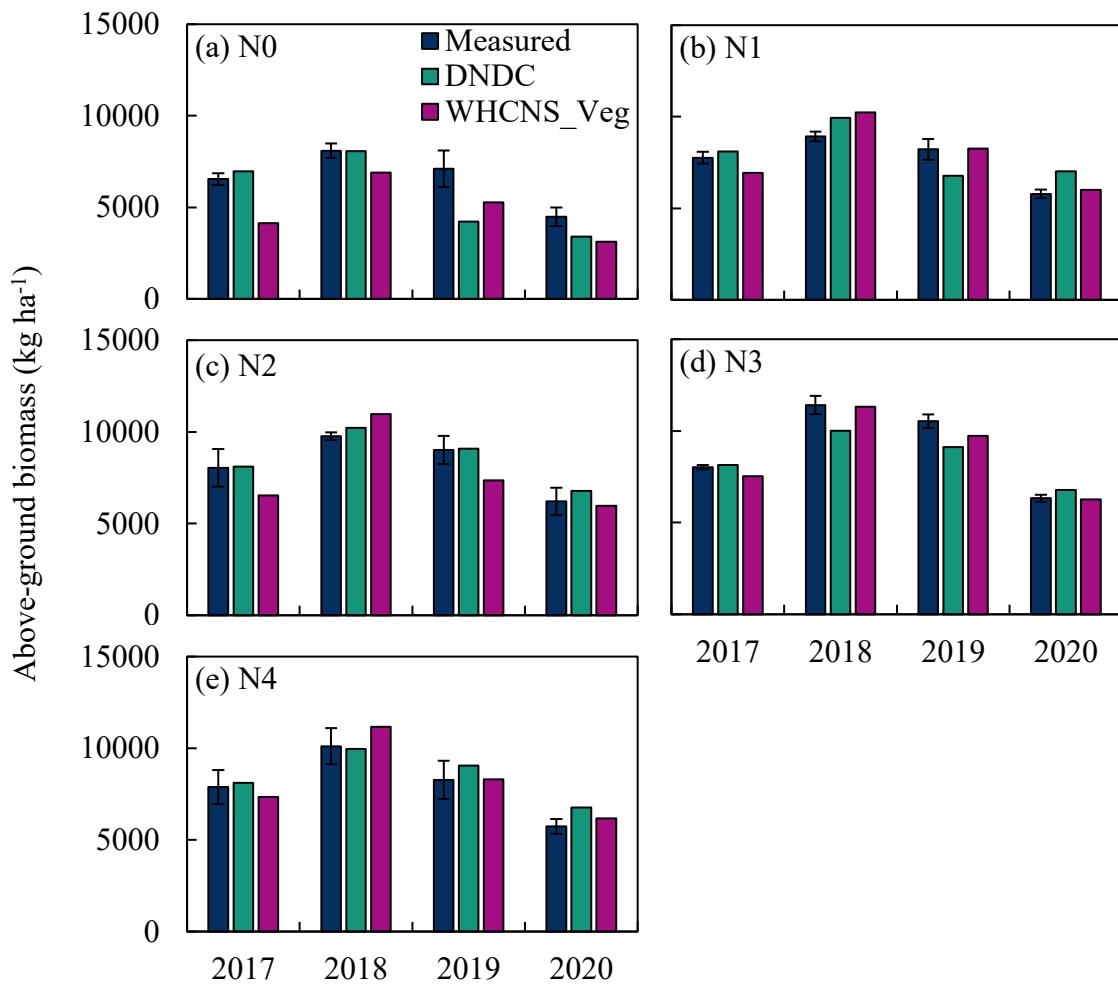


Figure S2. Measured and simulated potato above-ground biomass from 2017 to 2020 under different N application treatments using the DNDC and WHCNS_Veg models at Wuchuan, China. Vertical bars are standard deviations ($n = 3$).

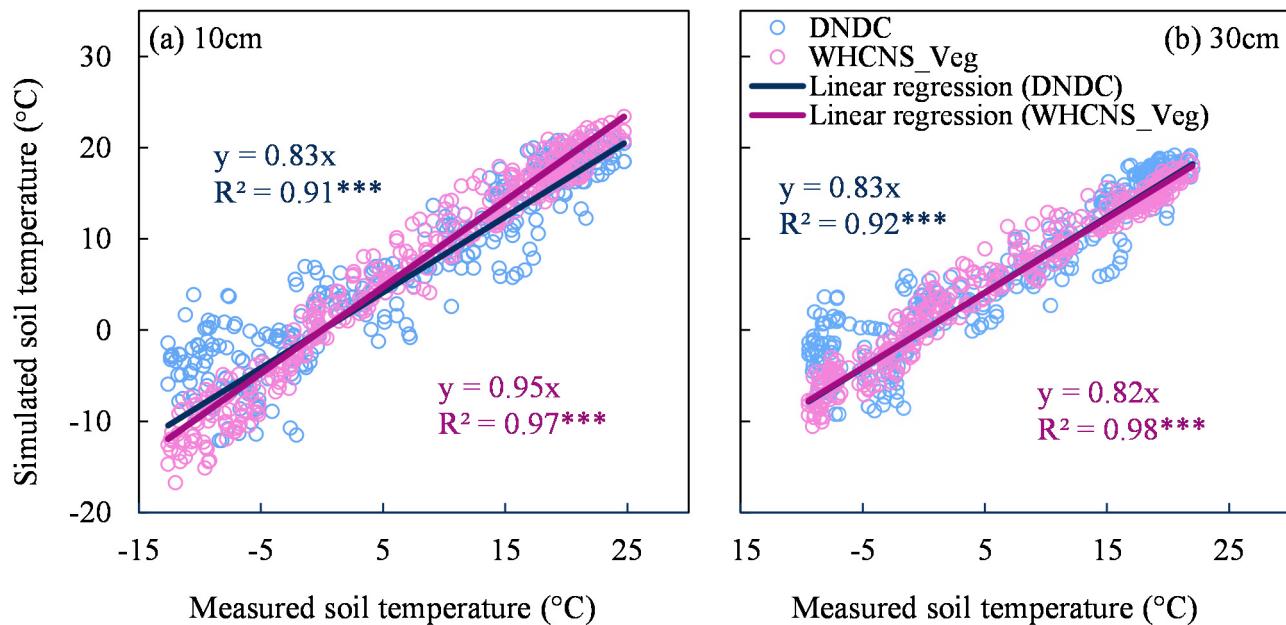


Figure S3. The linear regression between measured and simulated soil temperature ($n=365$) using the DNDC and WHCNS_Veg models at (a) 0.1 m and (b) 0.3 m soil depths. The R^2 with “***” indicates significant correlation at 0.001 probability level.

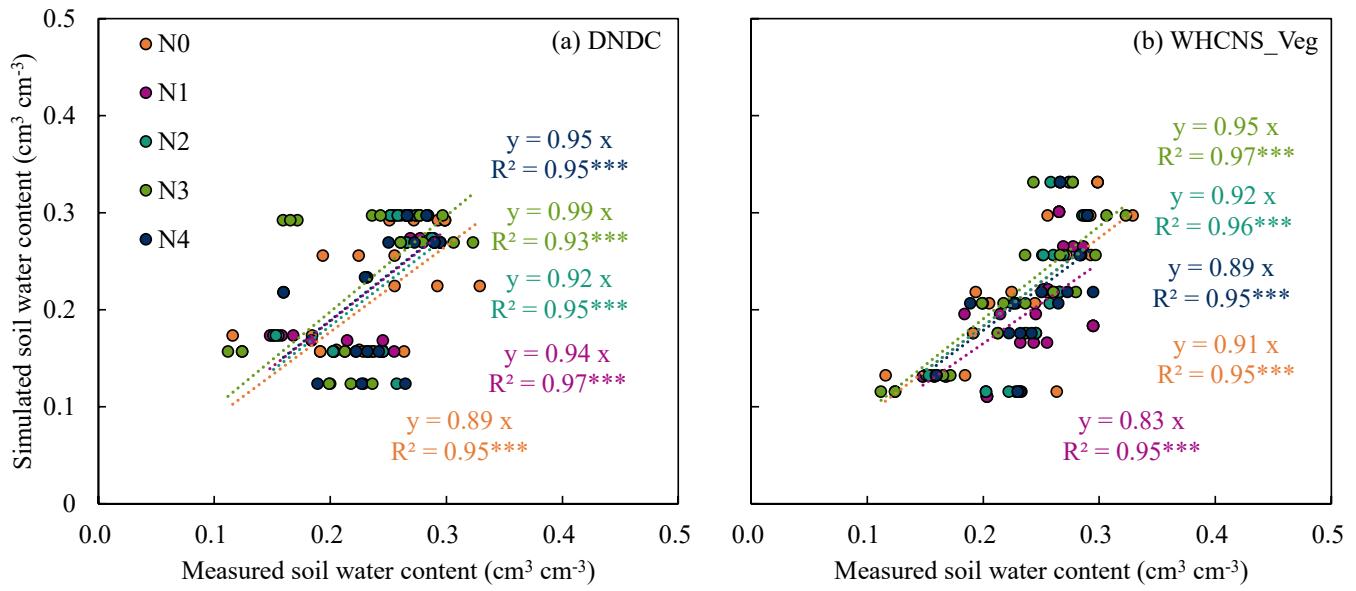


Figure S4. The linear regression between simulated and measured soil moisture ($n=24$) with (a) DNDC model and (b) WHCNS_Veg model for different treatments. The R^2 with “***” indicates significant correlation at 0.001 probability level.

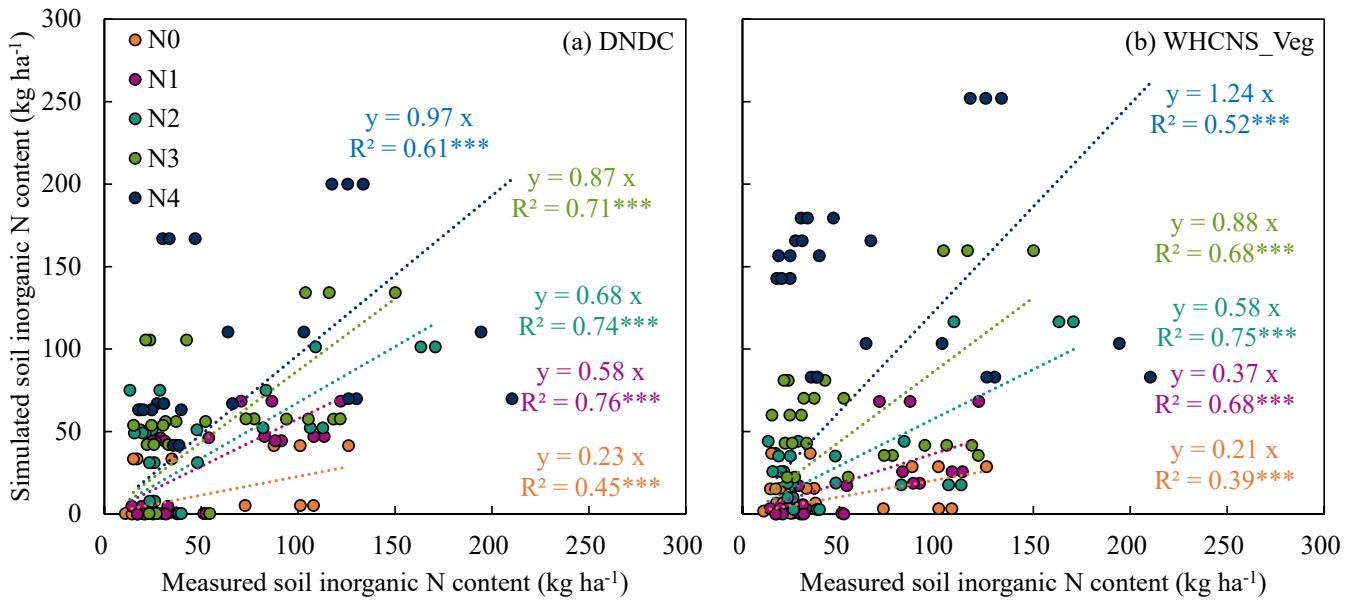


Figure S5. The linear regression between simulated and measured soil inorganic nitrogen content ($n=24$) with (a) DNDC and (b) WHCNS_Veg models for different treatments. The R^2 with “***” and “**” indicates significant correlation at 0.001 and 0.01 probability level.

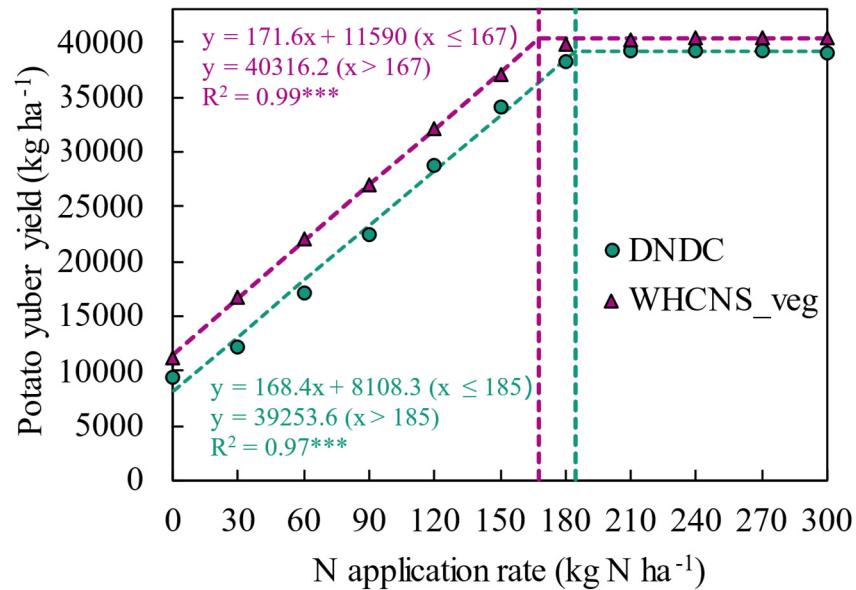


Figure S6. The linear plus platform regression between N application rate and simulated potato tuber yield using the DNDC and WHCNS_Veg model. The R^2 with “***” indicates significant correlation at 0.001 probability level.

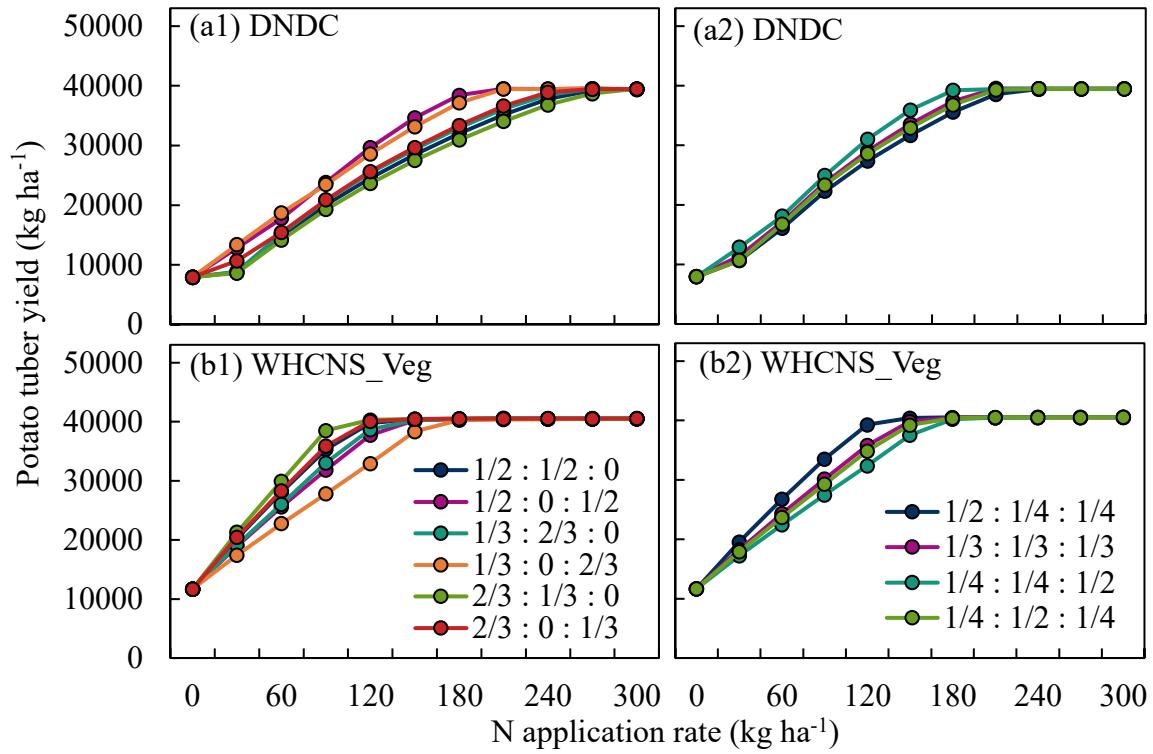


Figure S7. Sensitivity of potato tuber yields to N fertilizer application ratio of (a1 and b1) two-time splitting (fertilization at planting and emergence or tuber bulking stage) and (a2 and b2) three-time splitting (fertilization at planting, emergence and tuber bulking stage) in the (a1-2) DNDC and (b1-2) WHCNS_Veg model.