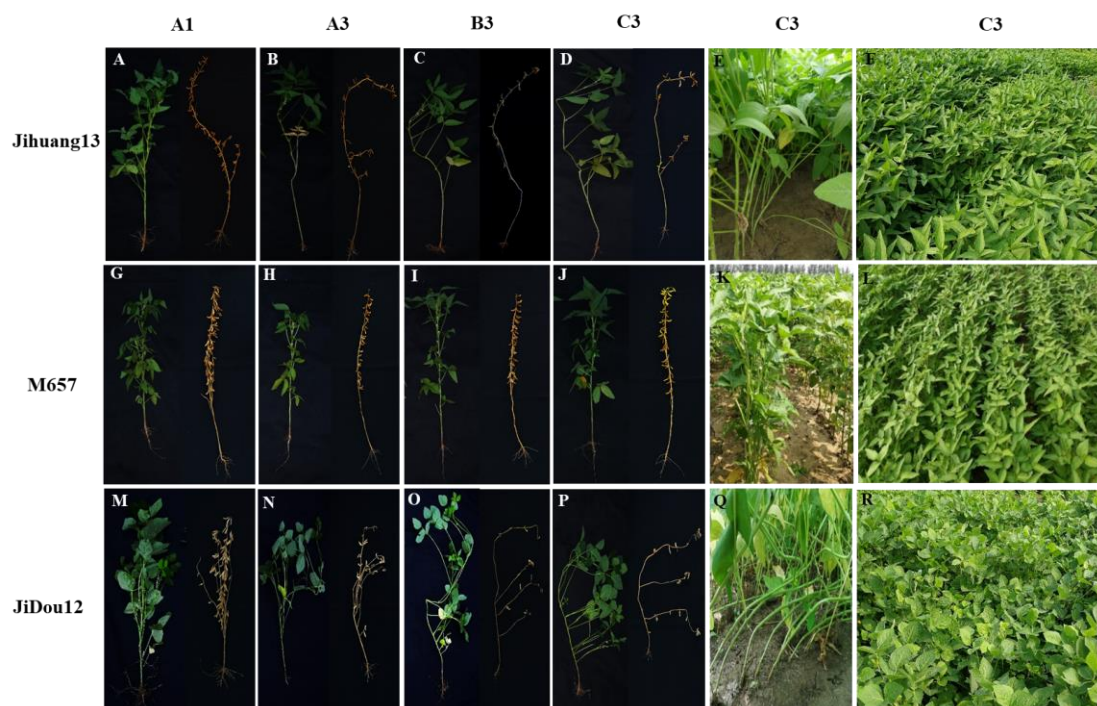




Appendix A Plant morphology of three varieties at 2018Beijing under four different planting densities. Variety (Horizontal): JH13, M657, JD12; Planting density gradient (Vertical): A1(conventional density, 20000 plants ha⁻¹), A3 (400200 plants ha⁻¹), B3 (500250 plants ha⁻¹), C3 (667000 plants ha⁻¹). These photographs were collected at full bloom (R2) and full maturity (R8)

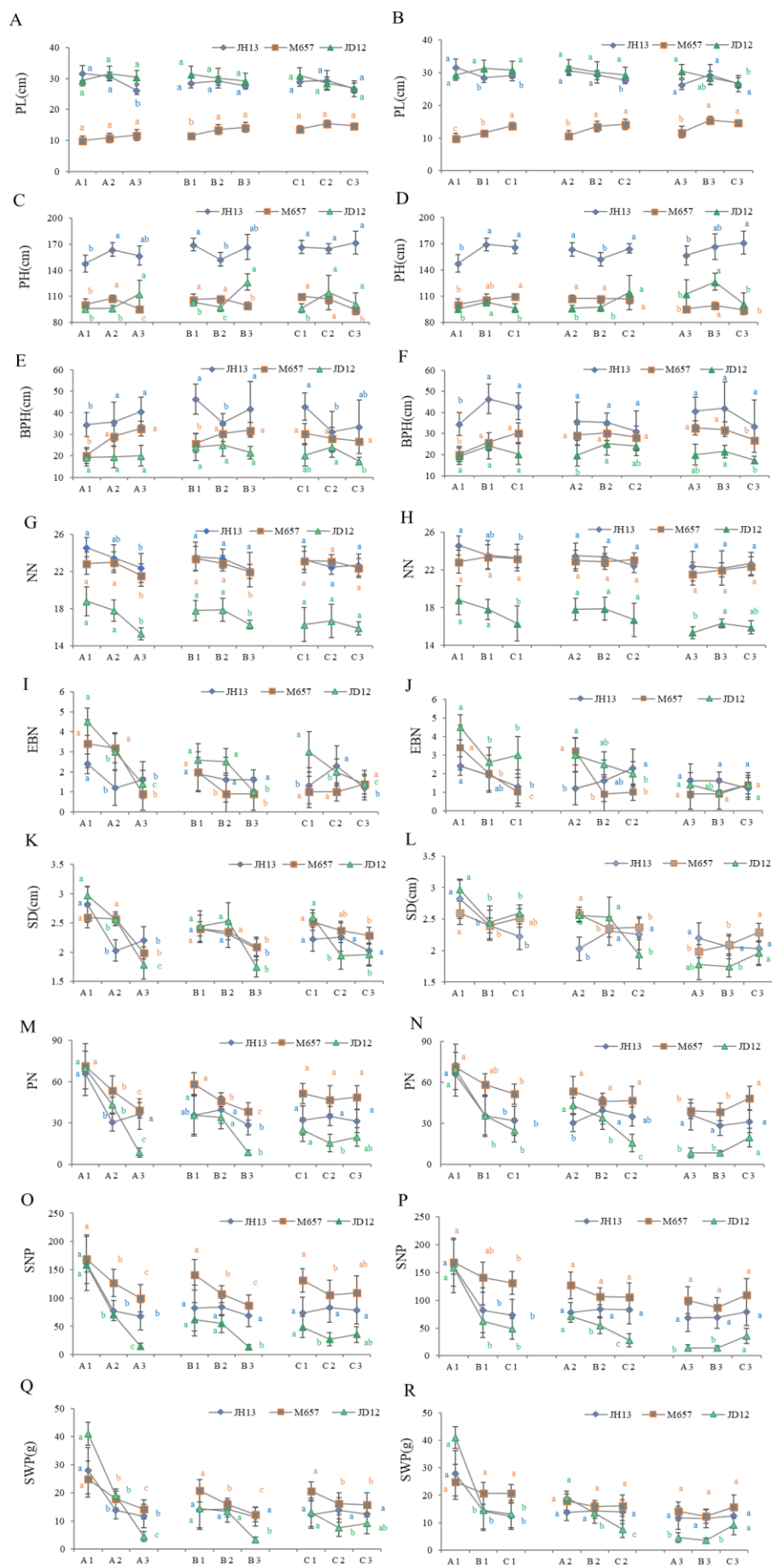
Appendix B Lodging grade of 4 germplasms at 4 growth stage in density experiment of 4 locations

Year/location	Germplasm	Growth stage	Density									
			A1	A2	A3	B1	B2	B3	C1	C2	C3	D3
2018BJ	JH13	R2	1	3	5	1	3	7	1	5	7	
		R4	1	3	7	1	7	9	3	9	9	
		R6	3	7	9	5	9	9	9	9	9	
		R8	3	7	9	5	9	9	9	9	9	
	M657	R2	1	1	1	1	1	1	1	1	1	
		R4	1	1	1	1	1	1	1	1	3	
		R6	1	1	3	1	3	5	1	3	5	
		R8	1	1	3	1	3	5	3	5	5	
	JD12	R2	1	1	3	1	1	5	1	3	5	
		R4	1	3	5	1	5	9	3	7	9	
		R6	1	3	9	3	5	9	5	9	9	
		R8	1	3	9	3	5	9	5	9	9	
2018SD	JH13	R2	1	1	1	1	1	3	1	3	5	
		R4	1	1	1	1	1	5	1	3	5	
		R6	1	1	1	1	3	5	3	5	9	
		R8	1	3	5	1	5	9	3	7	9	

Year/location	Germplasm	Growth stage	Density									
			A1	A2	A3	B1	B2	B3	C1	C2	C3	D3
2018HB	M657	R2	1	1	1	1	1	1	1	1	1	
		R4	1	1	1	1	1	1	1	1	1	
		R6	1	1	1	1	1	1	1	1	1	
		R8	1	1	1	1	1	1	1	1	1	
	HD5	R2	1	1	1	1	1	1	1	1	1	
		R4	1	1	3	1	3	3	1	3	7	
		R6	1	1	5	1	3	5	3	5	9	
		R8	1	1	7	1	5	9	5	7	9	
	JH13	R2				1	3	5				
		R4				1	5	7				
		R6				3	7	9				
		R8				3	7	9				
	M657	R2				1	1	1				
		R4				1	1	1				
2018HN	JD12	R6				1	3	3				
		R8				1	3	3				
		R2				1	3	3				
		R4				1	3	5				
	JH13	R6				1	5	7				
		R8				1	5	9				
		R2				1	1	1				
		R4				3	5	5				
	M657	R6				5	7	9				
		R8				9	9	9				
		R2				1	1	1				
		R4				1	1	1				
	HD5	R6				1	3	3				
		R8				1	3	3				
		R2				1	1	1				
		R4				1	1	5				
2017SD	JH13	R6				5	7	9				
		R8				5	9	9				
		R2	1		3							5
		R4	1		5							7
	M657	R6	1		9							9
		R8	1		9							9
		R2	1		1							1
		R4	1		1							1
	HD5	R6	1		1							1
		R8	1		1							1
		R2	1		3							3
		R4	1		5							5
	JH13	R6	1		5							7
		R8	1		7							9

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Appendix C Relationship between plant phenotype and density for three varieties in 2018BJ trials.

Effect of intra-row spacing (the left charts) on petiole length (PL, A), plant height (PH, C), bottom pod height (BPH, E), number of nodes on main stem (NN, G), effective branch number (EBN, I), stem diameter (SD, K), pod number per plant (PN, M), seed number per plant (SNP, O), and seed weight per plant (SWP, Q). Effect of inter-row spacing (the right charts) on petiole length (PL, B), plant height (PH, D), bottom pod height (BPH, F), number of nodes on main stem (NN, H), effective branch number (EBN, J), stem diameter (SD, L), pod number per plant (PN, N), seed number per plant (SNP, P), and seed weight per plant (SWP, R). Lowercase letters indicate significance differences between locations for the same trait in the same material; significance level is 0.05. The densities (inter-row space(cm)/ intra-row spacing(cm), planting density(plants ha⁻¹)) are A1(50/10, 200100), A2(50/7.5, 300150), A3(50/5, 400200), B1(40/10, 250125), B2(40/7.5, 375188), B3(40/5, 500250), C1(30/10, 333500), C2(30/7.5, 500250), C3(30/5, 667000), D3(30/5, 800400).

Appendix D High-yield Chinese soybean varieties and their yield performances

Year	Location	Name of Germplasm	Pedigree	Yield(kg ha ⁻¹)	Density (plants ha ⁻¹)	Reference
1994	Zhumadian, Henan	Youchu No.4	(Zaoshu No.3×Anhuidali-qing) Physical Mutagenesis	4618	2.03×10 ⁵	Zhang et al.1996[1]
1999	Shihezi, Xinjiang	Xindadou No.1	Gongjiao83289×Jilin33	5956. 2	3.20×10 ⁵	Luo et al.2011[2]
1999	Shihezi, Xinjiang	Shidadou No.1	Haijiao8403-73×Jilin 27	5407.8	2.50×10 ⁵	
1999	Xihua, Shanxi	Zhonghuang19	Zhongpin661×Yudou No.10	4838	1.87×10 ⁵	Wang et al.2013[3]
2005	Xianghuan, Shanxi	Zhonghuang19		4719	2.54×10 ⁵	
2000	Haicheng, Liaoning	Liao21051	Liao86-5433×Mercury	4908	3.30×10 ⁵	Song et al.2001[4]
2000	Mengcheng, Anhui	MN413	Wandou16 Mutagenesis×Yudou No.10	4726.2	1.58×10 ⁵	Li et al.2001[5]
2000	Jining, Shandong	JN96-2343	(Zaojufeng ×Zhongyi-tedali) F ₁ ×Gaofengdadou	4684.8	3×10 ⁵	Gai et al.2003[6]
2002	Dafeng, Jiangsu	Nannong88-31	Suxie No.1×7303-11-4-1	3001.5	2.4×10 ⁵	Zhao et al.2000[7]
2004	Xianghuan, Shanxi	Zhonghuang13	Yudou No.8×Zhong 90052-76	4686	2.22×10 ⁵	Hou et al.2009[8]
2005	Xianghuan, Shanxi	Zhonghuang13		4584	2.63×10 ⁵	Wang et al.2019[9]
2006-2010	Shihezi, Xinjiang	Zhonghuang35	(PI486355×Zheng8431) ×Zheng 6062	5317.5~6088.5 5722.88±280.51	2.26-3.14×10 ⁵	Wang et al.2011[10]
2009	Pulandian, Liaoning	Zhonghuang35		4503	3.5×10 ⁵	Wang et al.2013[3]
2011	Miyun, Beijing	Zhonghuang35		4872	1.87×10 ⁵	
2008	Harbin, Heilongjiang	Longxuan No.1	Hefeng25 Natural Variation	4893	-	[11]
2015/2017	Xinxiang, Hennan	Zhonghuang301	Zheng9525×Shangdou16	4720.5/4672.5	2.7×10 ⁵	Lu et al.2017[12] Yang et al.2017[13]
2016/2017	Shijiazhuang, Hebei	Jidou17	Hobbit×Zao5241	4,981.5/4,625.4/52 27.8	1.95×10 ⁵	
2013/2015/2016	Xinxiang, Hennan	ZhongzuoXA12938	-	4668/5044.2 /4720.5	3×10 ⁵	Lu et al.2017[12]
2017	Yuanyang, Henan	Zheng1307	Zheng9805×Zhoudou23	4,924.5	1.85×10 ⁵	
2017	Xinxiang, Hennan	Zheng196	Zheng100×Zheng93048	5127	1.85×10 ⁵	
2017	Suzhou, Anhui	Wandou37	Meng92-40-19×Hongyin No.3	3,586.05	-	
2018	Shihezi, Xinjiang	Henong91	Hobbit×Jiangmodou No.1	6356.55	6×10 ⁵	
2017	Shihezi, Xinjiang	Henong71	Sws1 -1(Sws1×Rocki) F ₂ -CO-r	6080. 85	3.15×10 ⁵	Guo et al.2019[14] Guo et al.2019[15]
2019	Shihezi, Xinjiang	Henong71		6712.05	3×10 ⁵	Liu.2019[16]

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