

Supplementary Table 1

Summary of information of the studies used in the meta-analysis: type of publication, the state of Brazil, environmental conditions (field, greenhouse, or seed lots), cultivation year, experimental factors evaluated in each study, average content of each macronutrient in soybean seeds, and number of observations obtained in each study.

Study Author(s) (year of publication)	State	E ¹	Year(s) of the study ²	Experimental factor evaluated	Average macronutrient content, in kg Mg ⁻¹ of seeds (number of observations)					
					N	P	K	Ca	Mg	S
Scientific paper					57.5³ (315)⁴	5.4 (468)	17.5 (431)	2.5 (344)	2.5 (360)	2.9 (227)
Aratani et al. (2007)	MS	F	2000/2001	Potassium (K) fertilization	-	-	14.0 ⁵ (8) ⁶	-	-	-
Bataglia et al. (1976)	SP	F	1973/1974	Nutrient uptake	64.6 (1)	5.2 (1)	22.5 (1)	-	2.9 (1)	1.9 (1)
Bataglia et al. (1977)	SP	F	1975/1976	Nutrient uptake	64.4 (7)	6.7 (5)	17.4 (8)	2.4 (8)	2.3 (8)	3.0 (8)
Bataglia et al. (1984)	SP	F	1973-1976	Fertilization	-	4.8 (30)	-	-	-	-
Batistella Filho et al. (2013)	SP	F	2009-2011	Phosphorus (P) and K fertilization	-	4.5 (16)	19.2 (16)	-	-	-
Caires et al. (2003)	PR	F	2001/2002	Lime application	55.3 (8)	5.4 (8)	14.8 (8)	1.9 (8)	1.7 (8)	-
Caires et al. (2006)	PR	F	2002-2004	Lime and gypsum applications	56.7 (8)	4.7 (8)	14.6 (8)	1.6 (8)	1.9 (7)	2.9 (8)
Campos and Gnatta (2006)	RS	F	1996-1998; 2000/2001	Inoculation seeds and foliar fertilization	58.7 (31)	-	-	-	-	-
Domingos et al. (2019)	PR	F	2014/2015	Foliar fertilization	-	4.5 (6)	16.2 (6)	2.5 (6)	2.8 (6)	2.6 (6)
Domingues de Souza et al. (2009)	MS	F	2006/2007	Foliar fertilization	-	7.4 (1)	20.2 (4)	1.8 (3)	2.7 (3)	3.6 (4)
Dorneles et al. (2015)	RS	F	2007/2008	Tillage and fertilization systems	60.2 (5)	5.5 (6)	15.9 (4)	2.7 (6)	2.4 (6)	-
Esper Neto et al. (2018)	PR	F	2015/2016	Foliar fertilization	68.3 (7)	5.0 (7)	16.6 (7)	2.0 (7)	2.0 (7)	2.4 (7)
Fageria et al. (2011)	TO	F	-	P fertilization	-	4.2 (10)	-	-	-	-

Ferreira et al. (2011)	RS	F	2007/2008	Integrated crop-livestock systems (ICLS)	-	-	19.5 (5)	-	-	-
Firmano et al. (2019)	PR	F	2015/2016	K fertilization	57.0 (12)	5.5 (12)	16.6 (12)	2.6 (12)	2.8 (12)	2.1 (12)
Foloni and Rosolem (2008)	SP	F	2000-2002	K fertilization	-	-	14.0 (32)	-	-	-
Francisco et al. (2007)	SP	F	2001/2002	Anticipation fertilization	64.6 (5)	4.7 (6)	16.1 (6)	1.5 (6)	2.0 (6)	2.3 (6)
Guimarães et al. (2003)	MS	F	1999/2000	Crop rotation, cover crops and fallow	64.4 (2)	5.8 (2)	16.5 (2)	-	2.6 (2)	3.5 (2)
Hickmann et al. (2017)	MG	F	2011/2012	Nitrogen (N), P, and K fertilization	-	-	19.2 (8)	-	-	-
Kurihara et al. (2013)	MS	F	2001/2002	High yield management	61.5 (1)	5.9 (1)	14.3 (1)	2.5 (1)	2.7 (1)	-
Lacerda et al. (2015)	MG	F	2010/2011; 2012/2013	N, P, and K fertilization	62.6 (16)	5.9 (16)	17.0 (16)	-	-	-
Magalhães et al. (2015)	MT	S ⁷	-	Nutrient content in seeds	58.0 (8)	5 (8)	16 (8)	2,8 (8)	2,5 (8)	2,2 (8)
Marin et al. (2015)	MT	F	2009/2010	P fertilization	58.0 (5)	6.5 (4)	19.6 (5)	3.1 (3)	2.1 (5)	3.5 (5)
Moreira and Moraes (2016)	PR	G	-	Sulfur (S) fertilization	63.7 (15)	6.0 (16)	21.7 (14)	2.4 (16)	2.4 (16)	2.7 (16)
Moreira and Moraes (2019)	PR	G	-	Cu fertilization	60.9 (10)	5.8 (9)	18.9 (10)	3.3 (10)	3.0 (10)	3.2 (10)
Moreira et al. (2015)	PR	F	2011-2013	N fertilization, row spacing, and plant density	56.1 (9)	5.9 (9)	21.0 (9)	3.1 (9)	2.6 (9)	2.7 (9)
Moreira et al. (2015b)	PR	G	-	K-use and K-uptake efficiency	59.7 (22)	5.1 (22)	15.6 (22)	1.8 (22)	2.0 (22)	2.6 (22)
Moreira et al. (2016)	PR	G	-	Content and uptake nutrients by seeds	56.0 (24)	5.5 (24)	17.6 (24)	2.6 (21)	2.4 (24)	2.8 (24)
Moreira et al. (2017)	PR	G	-	Lime application	52.9 (30)	5.9 (30)	17.9 (30)	3.2 (26)	2.5 (30)	3.0 (30)

Moreira et al. (2017b)	PR	F	2012-2015	Foliar fertilization	60.1 (11)	5.1 (11)	17.5 (11)	2.9 (11)	2.7 (11)	3.1 (11)
Moreira et al. (2017c)	PR	G	-	P-use efficiency	57.7 (25)	5.4 (13)	21.1 (9)	2.7 (18)	3.1 (14)	4.4 (9)
Moreira et al. (2018)	PR	G	-	P, K, and S fertilization	56.3 (9)	6.3 (1)	21.5 (1)	-	-	-
Moreira et al. (2019)	PR	F	2014-2016	Copper (Cu) fertilization	47.7 (3)	7.3 (2)	15.2 (5)	2.5 (5)	3.3 (4)	3.2 (5)
Motomiya et al. (2004)	MS	F	1997-1999	P fertilization	-	4.8 (20)	-	-	-	-
Oliveira et al. (2016)	GO	F	-	Soybean genotypic	-	5.0 (24)	-	-	-	-
Oliveira et al. (2019)	SP	F	2012-2014	N fertilization	48.4 (4)	-	-	-	-	-
Osório Filho et al. (2007)	RS	F	2004/2005	S fertilization	-	-	-	-	-	2.8 (4)
Souza et al. (2009)	MS	F	2005/2006	Seed treatments	-	5.2 (12)	18.1 (12)	2.6 (12)	2.4 (12)	2.7 (12)
Souza et al. (2018)	PR	F	2013-2015	Foliar fertilization	46.4 (7)	6.7 (9)	-	2.9 (9)	1.8 (9)	-
Souza et al. (2019)	PR	F	2015-2017	Foliar fertilization	48.5 (10)	5.7 (10)	15.3 (10)	-	2.3 (10)	-
Spehar et al. (1994)	DF	F	-	Lime application	-	5.7 (90)	18.4 (90)	2.4 (90)	2.5 (90)	-
Spehar et al. (1995)	DF	F	-	Content and uptake nutrients by seeds	-	5.7 (18)	18.3 (18)	2.3 (18)	2.5 (18)	-
Vargas et al. (1982)	DF	F	-	N fertilization	51.8 (10)	-	-	-	-	-
Vargas et al. (2018)	RS	S ⁸	2009-2012	Nutrient content in seeds	57.8 (1)	3.7 (1)	18.4 (1)	2.2 (1)	1.9 (1)	2.0 (1)
Zilli et al.(2010)	RR	F	2006-2008	Inoculation seeds	55.3 (7)	-	-	-	-	-
PhD thesis					58.5	4.3	14.9	2.4	2.65	2.75
					(31)	(28)	(174)	(34)	(30)	(29)
Conceição (2016)	-	S ⁹	2012-2014	Nutrient content in seeds and mineral supplements	60.3 (8)	4.2 (6)	14.5 (12)	2.3 (12)	-	-
Rigo (2016)	RS	S ¹⁰	2011/2012	Nutrient content in seeds	57.4 (9)	4.2 (9)	18.2 (9)	2.4 (9)	2.1 (9)	2.1 (8)
Schneider (2016)	PR	F	2013/2014	K fertilization	63.7 (4)	6.4 (4)	22.7 (3)	2.5 (4)	2.8 (4)	3.4 (4)
Souza (2008)	SP	F	2006/2007	Seed treatment and fertilization	56.0 (10)	3.5 (9)	14.7 (10)	2.5 (9)	2.7 (10)	1.9 (10)
Steiner (2014)	SP	F	2000-2012	K fertilization	-	-	14.6 (14)	-	2.9 (7)	4.1 (6)

Master dissertation					57.8	5.6	16.3	2.1	2.5	2.8
					(65)	(81)	(142)	(41)	(37)	(37)
Dierings (2012)	RS	F	2010/2011	K-use and K-uptake efficiency	-	-	17.6 (8)	-	-	-
Filho (2013)	GO	F	2011/2012	Management and K fertilization	-	-	16.8 (16)	-	-	-
Golfetto (2016)	PR	F	2014/2015	Potassium replacement	-	-	16.2 (7)	-	-	-
Gruberger (2016)	SP	F	2014/2015	Seed treatments	56.5 (5)	4.8 (5)	18.9 (5)	2.2 (5)	3.0 (5)	3.7 (5)
Inocêncio (2010)	MG	F	2009/2010	Zinc (Zn) replacement	56.9 (16)	5.0 (16)	14.1 (16)	2.0 (16)	1.9 (16)	2.7 (16)
Marcondes (2001)	PR	F	1999/2000	Seed treatment	60.5 (6)	-	-	-	-	-
Martinez (2002)	MS	F	2000/2001	Nutrient removal	57.9 (22)	6.0 (44)	18.7 (44)	-	-	-
Oliveira (2011)	MS	F	2009/2010	Soybean genotypic and weed management	60.1 (4)	5.5 (4)	13.1 (4)	1.5 (4)	2.9 (4)	3.8 (4)
Veiga (2007)	MG	F	2006/2007	K fertilization and liming	-	-	9.8 (3)	1.8 (4)	-	-
Xavier (2015)	GO	F	2013/2014	K fertilization	-	-	14.6 (15)	-	-	-
Zambiazzi (2014)	MG	F	2012/2013	K fertilization	-	-	12.4 (12)	-	-	-
Technical report and abstract					58.4	5.2	18.4	2.7	2.5	2.6
					(380)	(37)	(37)	(32)	(35)	(35)
Alves et al. (2005)	MS	F	2000-2002	N fertilization	56.5 (1)	-	-	-	-	-
Cordeiro et al. (1979)	SP	F	-	Nutrient uptake and removal	64.2 (22)	4.6 (22)	16.6 (22)	3.0 (19)	2.2 (22)	2.3 (22)
Esper Neto et al. (2019)	PR	F	2017/2018	Nutrient content in seeds	52.5 (12)	5.3 (12)	20.8 (12)	2.0 (12)	2.3 (12)	2.6 (12)
Oliveira Junior et al. (2014)	PR	F	2010-2012	Nutrient uptake	65.0 (1)	5.8 (1)	20.0 (1)	3.2 (1)	2.8 (1)	3.0 (1)
Soares et al. (2017)	RS	F	2014-2016	Nutrient budget	55.8 (2)	5.7 (2)	16.6 (2)	-	-	-

Total	57.8 (437)	5.4 (603)	16.7 (772)	2.5 (439)	2.4 (450)	2.8 (316)
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¹Experimental environment: F: field, G: greenhouse, S: seed lots.

²Year of the experimental trial

³Average content (kg Mg⁻¹ of seeds) of nutrients in each type of study

⁴Total number of observations per type of study

⁵Average content (kg Mg⁻¹ of seeds) of nutrients in each reference

⁶Total number of observations in each reference

⁷Average of three seed lots; ⁸average of 2,543 seed lots; ⁹average of two seed lots; ¹⁰average of 280 seed lot

Supplementary Table 2

Number of observations of N, P, K, Ca, Mg, and S concentrations in soybean seeds grouped over five decades (1971 to 2020) and distributed in different regions (South, Midwestern, Southeast, and North) and states of Brazil.

Grouping factor	Number of observations						Total of observations	
	N	P	K	Ca	Mg	S		
Decades								
1971-1980	30	28	31	27	31	31	178	
1981-1990	10	30	-	-	-	-	40	
1991-2000	-	108	108	108	108	-	432	
2001-2010	119	127	154	67	65	63	595	
2011-2020	278	310	479	237	246	222	1773	
Region State								
South	RS	48	18	29	16	16	13	140
	PR	235	214	209	205	216	193	1272
Midwest	MS	30	84	75	20	22	22	253
	MT	13	12	13	11	13	13	75
	GO	-	24	31	-	-	-	55
Southeast	DF	10	108	108	108	108	-	442
	SP	54	94	240	47	59	59	553
	MG	32	32	55	20	16	16	171
North	TO	-	10	-	-	-	-	10
	RR	7	-	-	-	-	-	7
Not informed		8	7	12	12	-	-	39
Total of observations		437	603	772	439	450	316	3017

The acronyms of the Brazilian states: RS: Rio Grande do Sul, PR: Paraná, MS: Mato Grosso do Sul, MT: Mato Grosso, GO: Goiás, DF: Distrito Federal, SP: São Paulo, MG: Minas Gerais, TO: Tocantins, and RR: Roraima.