

Appendix

Composite materials open field studies

Type of fertilizer	Studied Crop	Element	Studied Effect	Reference
ICF	<i>Triticum aestivum</i> L.	N	Yield, Aboveground biomass, N, P and K uptake	Murugappan and Mishra, 1979
SRF	<i>Oryza sativa</i> L.	N	N uptake, NUE	Li and Chen, 1980
SCU	<i>Poa pratensis</i> L. (Turfgrass)	N	Quality, Aboveground biomass (clipping yield), N uptake, Soil N	Hummel and Waddington, 1984
CRF, other SRF	<i>Poa pratensis</i> L. (Turfgrass)	N	Quality, Aboveground biomass (clipping yield), N uptake	Landschoot and Waddington, 1987
SCU	<i>Lolium perenne</i> L., <i>Festuca arundinacea</i> Schreb., <i>Dactylis glomerata</i> L., <i>Phalaris aquatica</i> L., <i>Holcus lanatus</i> L. (Grassland)	N	Plant establishment, Aboveground biomass	Pollock, 1988
PCF	<i>Lasthenia californica</i> , <i>Plantago erecta</i> , <i>Sitanion jubatum</i> , <i>Stipa pulchra</i> , etc. (Grassland)	N	Aboveground biomass, Number of species per area	Hobbs <i>et al.</i> , 1988
POC	<i>Zea mays</i> L.	N	N uptake	Shoji <i>et al.</i> , 1991
PCU	<i>Oryza sativa</i> L.	N	Yield, N uptake	Wada <i>et al.</i> , 1991
SRF	<i>Dactylis glomerata</i> L., <i>Poa pratensis</i> L. (Grassland)	N	Water quality	Owens <i>et al.</i> , 1992
SRF	<i>Zizania palustris</i> L.	NPK	Yield, N, Ca, P, Fe, K and S uptake, Profit optimization	Atkins <i>et al.</i> , 1992
PCF	<i>Oryza sativa</i> L.	N	Yield, N uptake	Stutterheim <i>et al.</i> , 1994
PCF	<i>Allium cepa</i> L.	N	Yield, Aboveground biomass (plant height, number of leaves)	Amans and Slangen, 1994
SRF	<i>Triodia basedowii</i> E.Pritz, <i>T. pungens</i> R.Br., ¹ <i>Plectrachne schinzii</i> Henr.	NPK	Soil N and P, Aboveground biomass, N and P uptake	Rice <i>et al.</i> , 1994
CRF	<i>Zea mays</i> L.	N	Soil N	Diez <i>et al.</i> , 1996
CRF	<i>Oryza sativa</i> L.	N	Yield, N uptake	Ando <i>et al.</i> , 2000
SRF	<i>Zea mays</i> L., <i>Triticum aestivum</i> L., <i>Avena sativa</i> L.	N	Yield, N uptake, Soil N	Diez <i>et al.</i> , 2000
CRF	<i>Lolium perenne</i> L.	N	Geese dropping density,	Patterson and Fuchs,

	(Grassland)		Aboveground biomass	2001
PCU	<i>Triticum aestivum</i> L.	N	Yield, Grain N	Haderlein <i>et al.</i> , 2001
POC	<i>Solanum tuberosum</i> L.	N	Yield, Quality, Net returns	Zvomuya and Rosen, 2001
PCU	<i>Oryza sativa</i> L.	N	N uptake, Aboveground biomass	Tuong <i>et al.</i> , 2002
PCU	<i>Allium cepa</i> L.	N	Yield, N uptake, Aboveground biomass, Leaf area, Soil N	Drost <i>et al.</i> , 2002
PCU, SCU, CRF	<i>Oryza sativa</i> L.	N	Yield, N ₂ fixation, N uptake, Plant height, Lodging %	Carreres <i>et al.</i> , 2003
CRF	<i>Lolium perenne</i> L. (Turfgrass)	N	GHG emissions, Soil N	Dobbie and Smith, 2003
PCF	<i>Oryza sativa</i> L.	NPK	Yield, SPAD, Plant height, Nutrients uptake (N, P, K, Ca, Mg, Si, Fe, Mn, Cu, Zn), Soil pH and Fe ₂ ⁺	Morikawa <i>et al.</i> , 2004
POC	<i>Zea mays</i> L.	N	Yield, GHG emissions, Soil microbial activity, N uptake	Chu <i>et al.</i> , 2004
PCU, CRF	<i>Poa pratensis</i> L., <i>Lolium perenne</i> L. (Turfgrass)	N	Quality, Aboveground biomass (clipping yield)	Miltner <i>et al.</i> , 2004
SRF, ICF	<i>Curcuma longa</i> L.	NPK	Yield, Aboveground biomass	Jagadeeswaran <i>et al.</i> , 2005
PCU	<i>Zea mays</i> L.	N	Urease activity, Microbial biomass C and N, Nematode communities	Jiao <i>et al.</i> , 2005
CRF	<i>Oryza sativa</i> L.	N	Yield, Lodging score, Internode length, N uptake	Shimono <i>et al.</i> , 2007
PCF	<i>Oryza sativa</i> L.	N	Yield, Aboveground biomass, N uptake	Castillo <i>et al.</i> , 2006
POC	Barley	N	Yield, GHG emissions, N and C uptake, Soil N	Chu <i>et al.</i> , 2007
SRF	<i>Paspalum notatum</i> Flugge, <i>Festuca</i> L. (Grassland)	Se	Se uptake	Valle <i>et al.</i> , 2002
POC	<i>Gossypium hirsutum</i> L.	N	Soil N, N uptake	Chen <i>et al.</i> , 2008
CRF	<i>Stenotaphrum secundatum</i> 'Floritam', <i>Dyopsis lutescens</i> , <i>Canna</i> × <i>generalis</i> 'Richard Wallace', <i>Pentas lanceolata</i> , <i>Allamanda cathartica</i> 'Hendersoni', <i>Nandina domestica</i>	K	Quality, Nutrients content (N, P, K, Mg, Fe, Mn)	Broschat <i>et al.</i> , 2008
PCU	<i>Solanum tuberosum</i> L.	N	Yield, Quality, N uptake, Soil N, Net returns	Wilson <i>et al.</i> , 2009
PCU	<i>Oryza sativa</i> L.	N	Yield, N uptake	Golden <i>et al.</i> , 2009

ICF, SCU	<i>Oryza sativa</i> L.	N	Quality	Bryant <i>et al.</i> , 2012
ICF, PCU	<i>Zea mays</i> L.	N	Yield, GHG emissions, N uptake	Venterea <i>et al.</i> , 2011
PCF, ICF	<i>Lolium perenne</i> L., <i>Poa pratensis</i> L., <i>Festuca rubra</i> spp. <i>commutata</i> Gaud and spp. <i>rubra</i> (Turfgrass)	N	Aboveground biomass, Quality	Bilgili and Açıkgöz, 2011
ICF, PCF	<i>Zea mays</i> L.	N	Yield, GHG emissions, Soil N, N uptake	Halvorson <i>et al.</i> , 2011
SRF	<i>Brassica juncea</i> L.	N	Yield, Aboveground biomass, N uptake	Sharma and Singh, 2011
SRF	<i>Brassica rapa</i> L.	N	Yield, N, P and K uptake	Okazaki <i>et al.</i> , 2012
SCU, ICF	<i>Daucus carota</i> L.	N	Yield, Plant stand, NDVI	Sanderson and Fillmore, 2012
PCU	<i>Triticum aestivum</i> L.	N	Yield, GHG emissions, Soil N	Ji <i>et al.</i> , 2012
PCU, ICF	<i>Zea mays</i> L.	N	Yield, GHG emissions, N uptake	Halvorson and Del Grosso, 2012
SRF, ICF	<i>Capsicum annuum</i> L.	N	Yield, N uptake, Aboveground biomass, Quality	Stagnari and Pisante, 2012
PCU	<i>Oryza sativa</i> L.	N	Yield, GHG emissions, Soil N	Ji <i>et al.</i> , 2013
CRU	<i>Zea mays</i> L.	N	Photosynthetic parameters	Qin <i>et al.</i> , 2013
PCF, SCU	<i>Zea mays</i> L.	NPK	Yield, N uptake, NH ₃ emissions, Photosynthetic rate	Zhao <i>et al.</i> , 2013
CRU	<i>Zea mays</i> L.	N	Yield, Photosynthetic parameters	Shao <i>et al.</i> , 2013
PCU	<i>Zea mays</i> L.	N	Yield, Plant height, SPAD, Grain quality	Nash <i>et al.</i> , 2013
PCU	<i>Triticum aestivum</i> L., <i>Zea mays</i> L.	N	Yield, Soil N, GHG emissions, Aboveground biomass	Hu <i>et al.</i> , 2013
SRF	<i>Lolium multiflorum</i> Lam. (Turfgrass)	NPK	Yield, Soil N, N uptake	Arrobas and Ângelo Rodrigues, 2013
PCF	<i>Triticum aestivum</i> L.	NPK	Yield, N uptake, Quality	Rajala and Peltonen-Sainio, 2013
CRF	<i>Triticum aestivum</i> L.	N	Root biomass and activity, Root/shoot ratio	Li <i>et al.</i> , 2014
SRF	<i>Solanum tuberosum</i> L.	NPK	Yield, N uptake, Aboveground biomass, WUE	Song <i>et al.</i> , 2014
SRF	<i>Zea mays</i> L.	N, P	Yield, Aboveground biomass, N and P efficiency	Guan <i>et al.</i> , 2014
SCU	<i>Zea mays</i> L.	N	Yield, Aboveground biomass, Plant height, LAI, Soil water dynamics	Liu <i>et al.</i> , 2015
SCU, other CRF	<i>Brassica rapa</i> L.	N	NH ₃ volatilization, Soil N and pH	Shan <i>et al.</i> , 2015a
SRF	<i>Zea mays</i> L.	N	Yield, C and N dynamics	Shang <i>et al.</i> , 2015
SCU, SRF	<i>Brassica rapa</i> L.	N	N losses (runoff), Vegetation coverage, Soil N	Shan <i>et al.</i> , 2015b
PCU, SCU	<i>Saccharum officinarum</i> L.	N	GHG emissions	Soares <i>et al.</i> , 2015

PCU	<i>Zea mays</i> L.	N	N loss (leaching)	Nash <i>et al.</i> , 2015
PCF, ICU	<i>Gossypium hirsutum</i> L.	N	GHG emissions	Watts <i>et al.</i> , 2015
SCU	<i>Oryza sativa</i> L.	N	Yield, N uptake, N losses (runoff and leaching), NH ₃ volatilization	Yang <i>et al.</i> , 2015
ICF, SRF	<i>Triticum aestivum</i> L.	N	Yield, GHG emissions, Soil N and C, Total biomass, Photosynthetic parameters	Bordoloi and Baruah, 2016
SCU	<i>Oryza sativa</i> L.	N	Yield, N losses (runoff)	Jang <i>et al.</i> , 2016
PCU	<i>Zea mays</i> L.	N	Yield, Aboveground biomass, SPAD, N uptake, Soil N	Shapiro <i>et al.</i> , 2016
SRF	<i>Oryza sativa</i> L.	N	Yield, GHG emissions, Soil N and DOC, NEEB (net ecosystem economic budget)	Zhang <i>et al.</i> , 2016a
PCU	<i>Oryza sativa</i> L.	N	Yield, Biomass, N uptake	Carvalho <i>et al.</i> , 2016
CRF	<i>Oryza sativa</i> L.	N	Yield, N uptake, N loss (leaching), Water quality	Zhang <i>et al.</i> , 2016b
ICF	<i>Zea mays</i> L.	N	GHG emissions, NH ₃ volatilization	Halvorson <i>et al.</i> , 2016
SRF	<i>Zea mays</i> L.	N	Yield, N uptake, Aboveground biomass, ETc, Soil N	Chilundo <i>et al.</i> , 2016
SCU	<i>Oryza sativa</i> L.	N	NH ₃ volatilization, GHG emissions	Sun <i>et al.</i> , 2016
PCF, SRF	<i>Lolium perenne</i> L., <i>Festuca rubra</i> L., <i>Festuca ovina</i> L. (Turfgrass)	NPK	Aboveground biomass, Plant height	Hric <i>et al.</i> , 2016a
ICF, PCU	<i>Saccharum officinarum</i> L.	N	Yield, Soil N, GHG emissions, N uptake	Wang <i>et al.</i> , 2016
SRF	<i>Lolium perenne</i> L., <i>Festuca rubra</i> L., <i>Festuca ovina</i> L. (Turfgrass)	NPK	Aboveground biomass, Turf height	Hric <i>et al.</i> , 2016b
CRF	<i>Momordica charantia</i> L.	N	Yield, Aboveground biomass, N uptake	Zhang <i>et al.</i> , 2018a
SRF	<i>Glycine max</i> (L.) Merr., <i>Zea mays</i> L.	K	Yield, Leaf K, Soil exchangeable K	Rosolem <i>et al.</i> , 2018
SRF	<i>Oryza sativa</i> L.	N	Yield, GHG emissions, Biogeochemistry, Microbial abundance	Kim <i>et al.</i> , 2017
SRF	<i>Sorghum bicolor</i> (L.) Moench	N	Soil N	Kabala <i>et al.</i> , 2017
ICF	<i>Oryza sativa</i> L.	N	Yield, GHG emissions, Soil parameters (N content, water soluble carbon, permanganate oxidizable carbon, enzymatic activity), Microbial population	Mohanty <i>et al.</i> , 2017
PCU	<i>Oryza sativa</i> L.	N	Yield, NH ₃ volatilization, Runoff and water quality, N uptake	Li <i>et al.</i> , 2017
ICF	<i>Oryza sativa</i> L.	N	GHG emissions	Van Trinh <i>et al.</i> , 2017

SRF	<i>Vigna unguiculata</i> (L.) Walp./ <i>Heliantus annuus</i> L., <i>Triticum aestivum</i> L./ <i>Pisum sativum</i> L.	N	Yield, Plant parameters (height, head diameter, seed)	Zohry <i>et al.</i> , 2017
POC	<i>Triticum aestivum</i> L., <i>Zea mays</i> L.	N	Yield, N uptake, Soil N	Shi <i>et al.</i> , 2018
CRF	<i>Camellia sinensis</i> L.	N	Yield, N uptake, GHG emissions, Soil N, DOC and pH	Wu <i>et al.</i> , 2018
PCF	<i>Oryza sativa</i> L.	N	Yield, Aboveground biomass, Soil N	Zhang <i>et al.</i> , 2018b
PCF	<i>Oryza sativa</i> L., <i>Triticum aestivum</i> L.	N	Yield, GHG emissions	Shakoor <i>et al.</i> , 2018
SCU, PCF	<i>Sorghum bicolor</i> (L.) Moench	N	Aboveground biomass, N and Cd concentration	Ruthrof <i>et al.</i> , 2018
PCU, ICF	<i>Oryza sativa</i> L.	N	Yield, GHG emissions, Aboveground biomass, LAI	Li <i>et al.</i> , 2018
PCU	<i>Triticum aestivum</i> L.	N	Yield, GHG emissions, N uptake, Soil N	Gao <i>et al.</i> , 2018
PCF	<i>Triticum aestivum</i> L., <i>Oryza sativa</i> L.	N	Nutrients and microbial soil dynamics	Liang <i>et al.</i> , 2019
SRF	<i>Triticum aestivum</i> L.	N	Yield, GHG emissions	Lyu <i>et al.</i> , 2019
CRF	<i>Oryza sativa</i> L.	N	Yield, Quality	Liu <i>et al.</i> , 2019
SCU, ICF	<i>Zea mays</i> L.	N	Energy auditing, Carbon footprint	Jat <i>et al.</i> , 2019
POC	<i>Oryza sativa</i> L.	N	Yield, N losses (runoff and leaching), N uptake	Husain <i>et al.</i> , 2019
PCU, biochar coating	<i>Pisum sativum</i> L. var <i>saccharatum</i> , <i>Cucurbita pepo</i> L., <i>Zea mays</i> L.	N	Yield, N uptake, SOM composition	Li <i>et al.</i> , 2019
PCU, ICF	<i>Oryza sativa</i> L.	N	Yield, NH ₃ volatilization, GHG emissions	Guo <i>et al.</i> , 2019
PCU	<i>Cynodon dactylon</i> × <i>C. transvaalensis</i> (Turfgrass)	NPK	N and P losses (runoff), Quality	Sanders and Beasley, 2019
PCF	<i>Oryza sativa</i> L.	Zn	Yield, Soil Zn and Fe, Zn and Fe uptake	Adhikary <i>et al.</i> , 2020
PCF	<i>Oryza sativa</i> L.	N	Yield, Photosynthetic parameters, Aboveground biomass, NUE	Gil-Ortiz <i>et al.</i> , 2020
SRF	<i>Zea mays</i> L.	N	Yield, GHG emissions, Quality	Chi <i>et al.</i> , 2020a
PCU, SCU	<i>Oryza sativa</i> L.	N	Yield, GHG emissions, Aboveground biomass, Soil Eh, Soil surface water depth	Sun <i>et al.</i> , 2020
SRF	<i>Daucus carota</i> L.	NPK	Yield, N uptake	Sikora <i>et al.</i> , 2020
SCU	<i>Oryza sativa</i> L.	N	NH ₃ volatilization, Water	Liu <i>et al.</i> , 2020

			quality	
CRF	<i>Zea mays</i> L.	K	Yield, Soil K, Ca and Mg, K uptake, Quality, SPAD, LAI	Li <i>et al.</i> , 2020a
PCF	<i>Zea mays</i> L.	N	Yield, N uptake, Aboveground biomass, Photosynthetic parameters	Li <i>et al.</i> , 2020b
PCU	<i>Lolium perenne</i> L. (Grassland)	N	GHG emissions, Soil N, Biomass, N uptake	Suter <i>et al.</i> , 2020
PCF, PCU, SCU	<i>Oryza sativa</i> L.	N	Yield, Aboveground biomass, N uptake, Leaf characteristics	Deng <i>et al.</i> , 2020
SRF	<i>Triticum aestivum</i> L., <i>Zea mays</i> L.	N	Yield, GHG emissions, Soil properties (conductivity, pH, C, C/N)	Chi <i>et al.</i> , 2020b
SRF, SCU	<i>Oryza sativa</i> L.	N	Yield, Aboveground biomass, N, P and K uptake, Net return	Yang <i>et al.</i> , 2020
SRF	<i>Brassica napus</i> L.	N	Yield, Quality, GHG emissions, Aboveground biomass, Plant height, SPAD, N uptake, Net income, Carbon footprint	Feng <i>et al.</i> , 2020

ICF, inhibitor coated fertilizer; SRF, slow release fertilizer; SCF, sulfur coated fertilizer; PCF, polymer coated fertilizer; POC, polyolefine coated certilizer; PCU, polymer coated urea; CRF, control release fertilizer.

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