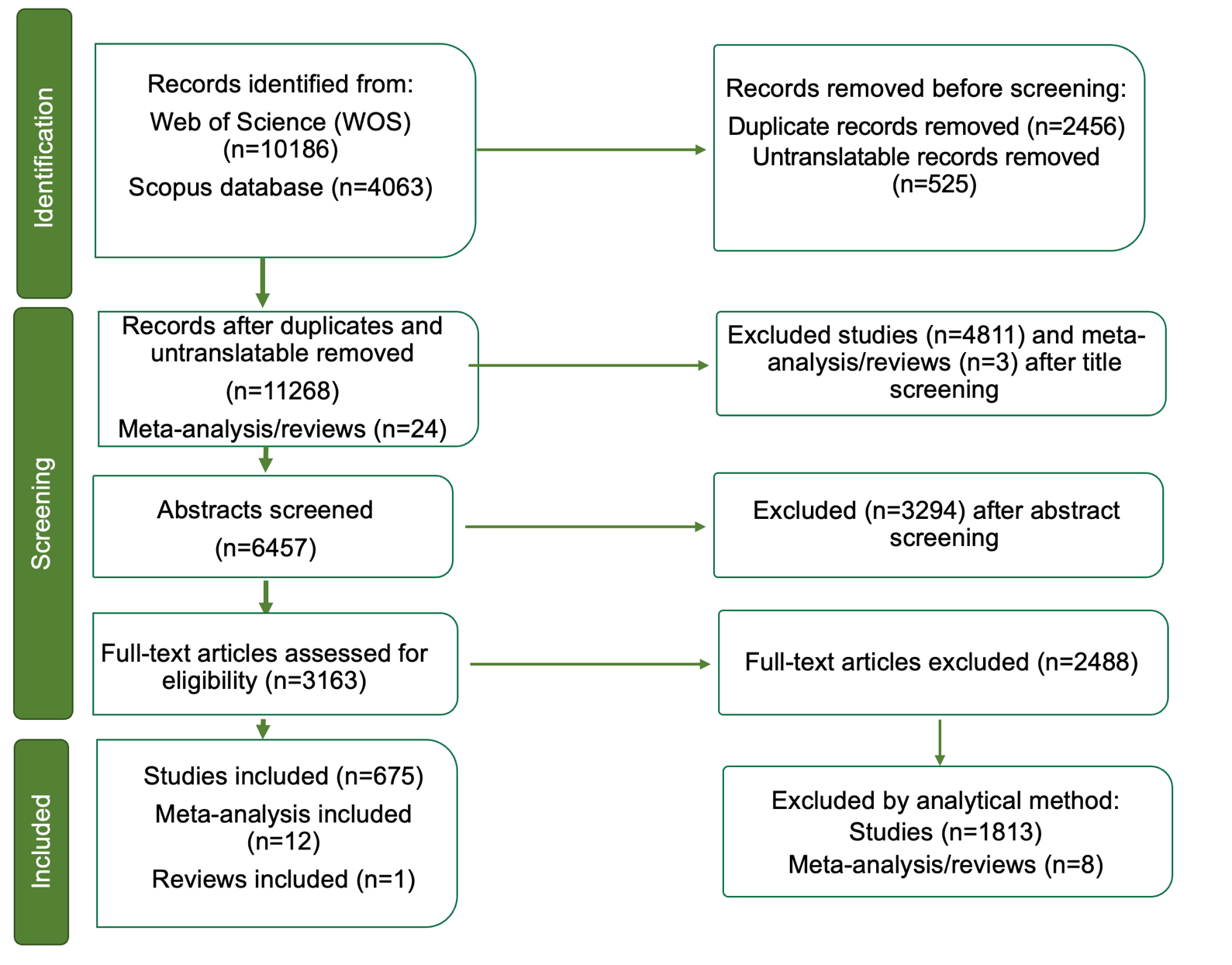
**Supplementary material – Relationship among soil biophysicochemical properties, agricultural practices and climate factors influencing soil phosphatase activity in agricultural land.**

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**Figure S1**. Article search and selection process.

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**Table Sa.** Comprehensive overview of meta-analyses and reviews investigating explanatory drivers for phosphatase activity (APase), including the total number of studies, enzyme analysis substrates, and ecosystem types.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Author and Year** | **Studies** | **Type** | **Substrates** | **Ecosystems** |
| Janes-Bassett et al. (2022) | 37 | Fertilization | Disodium-p-nitrophenyl phosphate among others | Farmland, grassland |
| Miao et al. (2019) | 85 | Fertilization | Disodium-p-nitrophenyl phosphate, 4-MUB-phosphate | Farmland |
| Jian et al. (2016) | 65 | Fertilization | Disodium-p-nitrophenyl phosphate, 4-MUB-phosphate | Farmland, grassland, forest, peat |
| Marklein and Houlton, (2012) | 34 | Fertilization | Disodium-p-nitrophenyl phosphate among others | Grassland, shrubland, forest, tundra, wetland |
| Pokharel et al. (2020) | 72 | Fertilization esp.Biochar | Disodium-p-nitrophenyl phosphate among others | Based on textural classes |
| Lin et al. (2021) | 73 | Pollution | Disodium-p-nitrophenyl phosphate among others | Arable land, grassland |
| Aponte et al. (2020) | 46 | Pollution | Disodium-p-nitrophenyl phosphate among others | Based on soil (cutivated and uncultivated) |
| Riah et al. (2014) | 47 | Pollution | Disodium-p-nitrophenyl phosphate | Agricultural landscapes, microcosms |
| Margalef et al. (2017) | 183 | Soil properties/ Climatic | Disodium-p-nitrophenyl phosphate, diso-dium phenyl phosphate, 4-methyl umbelliferyl phosphate | Soil forest, shrublands, grasslands |
| Margalef et al. (2021) | 97 | Climatic | Disodium-p-nitrophenyl phosphate, diso-dium phenyl phosphate, 4-methyl umbelliferyl phosphate | Soil forest, shrublands, grasslands |
| Gao et al. (2020) | 79 | Climatic | Disodium-p-nitrophenyl phosphate | Cropland, grassland, forest, wetland, shrubland, wasteland, open area, |
| Meng et al. (2020) | 78 | Climatic | Disodium-p-nitrophenyl phosphate among others | Farmland, forest, grassland, peatland, shrubland, tundra |
| Sun et al. (2020) | 139 | Climatic | Disodium-p-nitrophenyl phosphate, diso-dium phenyl phosphate, 4-methyl umbelliferyl phosphate | Soil forest, shrublands, grasslands |

**Table Sb.** Comprehensive overview of meta-analyses and reviews detailing factors influencing phosphatase activity (APase), encompassing number of observations, drivers, variables and acid and alkaline phosphatase (ACP and ALP, respectively) response.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Reference** | **Number of observations\*** | **Driver** | **Variable** | **APase** | **Response** |
| Jian et al., 2016 | 16 | Fertilization | N | ACP | Positive |
| Marklein and Houlton, 2012 | 112 | Fertilization | N | ACP, ALP | Positive |
| Marklein and Houlton, 2012 | 112 | Fertilization | P | ACP, ALP | Positive |
| Margalef et al., 2021 | 50 | Fertilization | N | ACP, ALP | Positive |
| Margalef et al., 2021 | 24 | Fertilization | P | ACP, ALP | Negative |
| Margalef et al., 2021 | 49 | Fertilization | N, P | ACP, ALP | Negative |
| Janes-Bassett et al., 2022 | 163 | Fertilization | P | Monoesterases (unspecified) | None |
| Miao et al., 2018 | 46 | Fertilization | Chemical fertilizer  (unbalanced application, NPK) | ACP, ALP | Positive |
| Miao et al., 2018 | 19 | Fertilization | Organic fertilizer  (straw residue retention, manure) | ACP, ALP | Positive |
| Miao et al., 2018 | 35 | Fertilization | Chemical+Organic  (NPK+straw, NPK+manure) | ACP, ALP | Positive |
| Pokharel et al., 2020 | 37  23 | Fertilization | Biochar | ACP  ALP | Positive  None |
| Riah et al., 2014 | 4  5 | Pollution | Herbicide | ACP  ALP | None  None |
| Riah et al., 2014 | 4  5 | Pollution | Fungicide | ACP  ALP | Positive  Negative |
| **Reference** | **Number of observations\*** | **Driver** | **Variable** | **APase** | **Response** |
| Riah et al., 2014 | 6  8 | Pollution | Insecticide | ACP  ALP | Negative  Positive/ none |
| Aponte et al., 2020 | 103  67  103  67 | Pollution | Pb, Zn, As  Cu, Cd | ACP  ALP  ACP  ALP | Negative  Negative  Positive  Negative |
| Lin et al., 2021 | 27  13 | Pollution | C, Cu, Ag NMs  Fe NMs | ACP  ALP  ACP  ALP | Negative  Positive |
| Sun et al., 2020 | 139 | Climate | MAT  MAP | ACP | Positive |
| Meng et al., 2020 | 78 | Climate | MAT | ACP  ALP | Positive |
| Margalef et al., 2021 | 13 | Climate | MAT | ACP, ALP | None |
| Margalef et al., 2021 | 11 | Climate | Drought | ACP, ALP | Negative |
| Margalef et al., 2021 | 37 | Climate | CO2 fertilization | ACP, ALP | Positive |
| Gao et al., 2020 | 97  15 | Climate | Drought | ACP  ALP | Negative |

\* When data is accessible, the number of observations evaluating APase activity in cropland, farmland, and grassland is provided.

**Tables S1 to S18**

Summary and comprehensive tables inclusive of references.

*Table S1. Single studies of APase response relationships to soil microbe and fauna factors.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Soil microbe/fauna factor** | **APase** | **Response relationship** | **Vote counting** | **Study** |
| Total microbe activity | ACP | Positive | 9 | Boccolini et al., 2019; |
|  |  |  |  | Bolton et al., 1985; |
|  |  |  |  | Chellappa et al., 2021; |
|  |  |  |  | Datta et al., 2021; |
|  |  |  |  | Nath et al., 2017; |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  |  | Radhakrishnan et al., 2022; |
|  |  |  |  | Stegarescu et al., 2021; |
|  |  |  |  | Tu C.M., 1995; |
|  | ALP | Positive | 4 | Datta et al., 2021; |
|  |  |  |  | Delgado et al., 2012; |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  |  | Singh et al., 2022; |
| Microbe abundance | ACP | Positive | 11 | Carricondo-Martínez et al., 2022; |
|  |  |  | Chen et al., 2018; |
| (Bacteria, Actinobacteria, Fungi) |  |  |  | Chowdhury and Rasid, 2021b; |
|  |  |  |  | Dolker et al., 2020; |
|  |  |  |  | Idris and Yuliar, 2021; |
|  |  |  |  | Li et al., 2002; |
|  |  |  |  | Meher et al., 2021; |
|  |  |  |  | Sanchez-Peinado et al., 2009; |
|  |  |  |  | Swędrzyńska et al., 2013; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Yu et al., 2021; |
|  | ALP | Positive | 12 | Al-Taweel et al., 2019; |
|  |  |  |  | Firmano et al., 2021; |
|  |  |  |  | Idris and Yuliar, 2021; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Li et al., 2017a; |
|  |  |  |  | Li et al., 2002; |
|  |  |  |  | Meher et al., 2021; |
|  |  |  |  | Niewiadomska et al., 2016; |
|  |  |  |  | Tamilselvi et al., 2015; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Xu et al., 2019; |
|  |  |  |  | Yu et al., 2021; |
| Microbial biomass phosphorus content | ACP | Positive | 6 | Basak and Gajbhiye, 2018; |
|  |  |  |  | de Jesus Franco et al., 2020; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Moharana et al., 2022; |
|  |  |  |  | Redel et al., 2011; |
|  |  |  |  | Turner and Haygarth, 2005; |
|  | ALP | Positive | 6 | Basak and Gajbhiye, 2018; |
|  |  |  |  | Hu et al., 2009a; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Moharana et al., 2022; |
|  |  |  |  | Touhami et al., 2021; |
|  |  |  |  | Zhou et al., 2022; |
| Microbial biomass carbon content | ACP | Positive | 36 | Ansari et al., 2021; |
|  |  |  |  | Antolín et al., 2005; |
|  |  |  |  | Arora et al., 2021; |
|  |  |  |  | Balota et al., 2011b; |
|  |  |  |  | Banerjee et al., 1999; |
|  |  |  |  | Bhattacharyya et al., 2003; |
|  |  |  |  | Biswas et al., 2018; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Choudhary et al., 2021; |
|  |  |  |  | Chowdhury and Rasid, 2021a; |
|  |  |  |  | Chowdhury and Rasid, 2021b; |
|  |  |  |  | da Cunha et al., 2021; |
|  |  |  |  | de Barros et al., 2019; |
|  |  |  |  | de Castro Lopes et al., 2013; |
|  |  |  |  | de Jesus Franco et al., 2020; |
|  |  |  |  | Feng et al., 2021; |
|  |  |  |  | Furtak et al., 2017; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Hazarika et al., 2009; |
|  |  |  |  | He et al., 2010; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Li et al., 2012; |
|  |  |  |  | Liu et al., 2008; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Mahajan et al., 2021; |
|  |  |  |  | Mandal et al., 2007; |
|  |  |  |  | Pascual et al., 2007; |
|  |  |  |  | Rouydel et al., 2021; |
|  |  |  |  | Roy et al., 2019; |
|  |  |  |  | Sarkar et al., 2009; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Tamilselvi et al., 2015; |
|  |  |  |  | Turner and Haygarth, 2005; |
|  |  |  |  | Tuti et al., 2020; |
|  |  |  |  | Wei et al., 2017; |
|  |  |  |  | Woźniak et al., 2022; |
|  |  | Negative | 1 | Bera et al., 2016; |
|  | ALP | Positive | 38 | Acosta-Martínez et al., 2004; |
|  |  |  |  | Acosta-Martínez et al., 2011a; |
|  |  |  |  | Arora et al., 2021; |
|  |  |  |  | Bera et al., 2016; |
|  |  |  |  | Bissonette et al., 2001; |
|  |  |  |  | Biswas et al., 2018; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Chander et al., 1997; |
|  |  |  |  | Chaudhary et al., 2015; |
|  |  |  |  | Choudhary et al., 2021; |
|  |  |  |  | Dar G., 1996; |
|  |  |  |  | Dong et al., 2016; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | He et al., 2010 |
|  |  |  |  | Hojati and Nourbakhsh, 2006; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Kaur et al., 2017; |
|  |  |  |  | Li et al., 2017a; |
|  |  |  |  | Li et al., 2012; |
|  |  |  |  | Liu and Zhou, 2017; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Madejón et al., 2007 |
|  |  |  |  | Mandal et al., 2007 |
|  |  |  |  | Mbarki et al., 2010 |
|  |  |  |  | Melero et al., 2007a; |
|  |  |  |  | Pascual et al., 2007 |
|  |  |  |  | Rouydel et al., 2021; |
|  |  |  |  | Roy et al., 2019; |
|  |  |  |  | Sarkar et al., 2009; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Tamilselvi et al., 2015; |
|  |  |  |  | Tripathi et al., 2007; |
|  |  |  |  | Tuti et al., 2020; |
|  |  |  |  | Verma et al., 2016b; |
|  |  |  |  | Wang et al., 2014a; |
|  |  |  |  | Wick et al., 1998; |
|  |  |  |  | Zhao et al., 2009; |
| Microbial biomass nitrogen content | ACP | Positive | 10 | Ajwaa et al., 1999; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | de Jesus Franco et al., 2020; |
|  |  |  |  | Furtak et al., 2017; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Sarkar et al., 2009; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Woźniak et al., 2022; |
|  | ALP | Positive | 10 | Acosta-Martínez et al., 2011a; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Dong et al., 2016; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Mandal et al., 2007 |
|  |  |  |  | Sarkar et al., 2009; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Sudhakaran et al., 2019; |
| Microbe diversity  (Shannon diversity index) | ACP | Positive | 3 | Diallo-Diagne et al., 2016; |
|  |  |  | Sun et al., 2018; |
|  |  |  |  | Woźniak et al., 2022; |
|  | ALP | Positive | 2 | Cao et al., 2021; |
|  |  |  |  | Liu et al., 2021a; |
| phoD gene abundance and richness | ALP | Positive | 3 | Bi et al., 2020 |
|  |  |  |  | Gou et al., 2020; |
|  |  |  |  | Wang et al., 2022c; |
| Earthworm abundance | ACP | Positive | 2 | Noronha et al., 2022; |
|  |  |  |  | Saha et al., 2008a; |
|  |  | None | 1 | Wu et al., 2012; |
|  | ALP | Positive | 3 | Balachandar et al., 2021; |
|  |  |  |  | Buck et al., 2000; |
|  |  |  |  | Tao et al., 2009; |
|  |  | None | 1 | Stoven and Schnug, 2009; |

*Table S2. Single and meta-analysis studies of APase response relationships to soil physical properties.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Soil property** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Depth | ACP1 | Negative | 26 | ﻿Baligar et al., 2005; |
|  |  |  |  | Bolton et al., 1993; |
|  |  |  |  | Cao et al., 2021; |
|  |  |  |  | de Barros et al., 2019; |
|  |  |  |  | de Castro Lopes et al., 2021; |
|  |  |  |  | Denton et al., 2006; |
|  |  |  |  | Fialho et al., 2008; |
|  |  |  |  | Firmano et al., 2021; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Guo et al., 2009 |
|  |  |  |  | Kahle et al., 2010; |
|  |  |  |  | Kumar et al., 2021a; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Rao et al., 1995; |
|  |  |  |  | Sigua et al., 2017; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Taylor et al., 2002; |
|  |  |  |  | Tiecher et al., 2012; |
|  |  |  |  | Trujillo-Narcía et al., 2019; |
|  |  |  |  | Venkatesan et al., 2006 |
|  |  |  |  | Wang et al., 2011c; |
|  |  |  |  | Wang et al., 2012; |
|  |  |  |  | Yoshioka et al., 2006; |
|  |  |  |  | Zhang et al., 2016b; |
|  |  |  |  | Zhong et al., 2015; |
|  |  |  |  | Zhu et al., 2022; |
|  | ALP1 | Negative | 18 | Cao et al., 2021; |
|  |  |  |  | Caudle et al., 2020; |
|  |  |  |  | de Barros et al., 2019; |
|  |  |  |  | Dou et al., 2016; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Guo et al., 2009 |
|  |  |  |  | Jat et al., 2019; |
|  |  |  |  | Kumar et al., 2021a; |
|  |  |  |  | Lalande et al., 2009; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Mahmood et al., 2022; |
|  |  |  |  | Melero et al., 2008b; |
|  |  |  |  | Melero et al., 2011; |
|  |  |  |  | Rao et al., 1995; |
|  |  |  |  | Rao et al., 1997; |
|  |  |  |  | Stehouwer et al., 1993; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Zhang et al., 2018; |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Soil moisture content | ACP1 | Positive | 5 | Gispert et al., 2013; |
|  |  |  |  | Hoyle and Murphy, 2006; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Omenda et al., 2019; |
|  |  |  |  | Stegarescu et al., 2021; |
|  | ALP1 | Positive | 2 | Gangwar et al., 2021; |
|  |  |  |  | Monaci et al., 2022; |
|  |  | None | 1 | Wang et al., 2022a; |
| Clay content | ACP1 | Positive | 10 | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Bossio et al., 2005; |
|  |  |  |  | Cycoń et al., 2013; |
|  |  |  |  | Cycoń Piotrowska-Seget, 2015; |
|  |  |  |  | de Castro Lopes et al., 2013; |
|  |  |  |  | Fernández et al., 2008; |
|  |  |  |  | Mejia Guerra et al., 2018; |
|  |  |  |  | Nedyalkova et al., 2020; |
|  |  |  |  | Nedyalkova et al., 2020; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  | ALP1 | Positive | 21 | Abdalla and Lager, 2009; |
|  |  |  |  | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Acosta-Martínez et al., 2003a; |
|  |  |  |  | Banerjee et al., 2008; |
|  |  |  |  | Bergstrom and Monreal,1998a; |
|  |  |  |  | Calvarro et al., 2014; |
|  |  |  |  | Cycoń et al., 2013; |
|  |  |  |  | Dar G., 1996; |
|  |  |  |  | Fernández et al., 2008; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Li et al., 2018c; |
|  |  |  |  | Łukowski and Dec, 2018; |
|  |  |  |  | Mahmood et al., 2022; |
|  |  |  |  | Melero et al., 2007a; |
|  |  |  |  | Senwo et al., 2007; |
|  |  |  |  | Stehouwer et al., 1993; |
|  |  |  |  | Stenberg et al., 1998; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Tavali et al., 2021; |
|  |  |  |  | Vekemans et al., 1989; |
|  |  |  |  | Wyszkowska et al., 2005; |
|  | ACP, ALP2 | Positive | 1 | Aponte et al., 2020; |
| Sand content | ACP1 | Positive | 1 | Acosta-Martínez et al., 2003b; |
|  |  | Negative | 3 | Fernández-Calviño et al., 2010; |
|  |  |  |  | Nedyalkova et al., 2020; |
|  |  |  |  | Woźniak et al., 2022; |
|  | ALP1 | Positive | 3 | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Bergstrom and Monreal, 1998a; |
|  |  |  |  | Wyszkowska et al., 2005; |
|  |  | Negative | 3 | Garg and Bahl, 2008; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Łukowski and Dec, 2018; |
| Microaggregate content (<0.25 mm) | ACP1 | Negative | 1 | Wei et al., 2014b; |
| ALP1 | Negative | 2 | Sharma et al., 2019a; |
|  |  |  |  | Wei et al., 2014a |

*Table S3. Single and meta-analysis studies of APase response relationships to soil pH and associated factors.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Soil pH factor** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| pH | ACP1 | Negative at pH >7 | 50 | Acosta-Martínez and Tabatai, 2000; |
|  |  |  |  | Alvarenga et al., 2008; |
|  |  |  |  | Bachmann et al., 2014; |
|  |  |  |  | Balota et al., 2011b; |
|  |  |  |  | Bera et al., 2016; |
|  |  |  |  | Bi et al., 2020; |
|  |  |  |  | Biswas et al., 2018; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Caballero Vanegas et al., 2018; |
|  |  |  |  | Chakrabarti et al., 2000; |
|  |  |  |  | Chang et al., 2007; |
|  |  |  |  | Chen et al., 2021a; |
|  |  |  |  | Dick et al., 2000; |
|  |  |  |  | Fernández-Calviño et al., 2010 |
|  |  |  |  | Firmano et al., 2021; |
|  |  |  |  | Futa et al., 2021; |
|  |  |  |  | Gaind and Nain, 2015b; |
|  |  |  |  | Ghiloufi and Chaieb, 2021; |
|  |  |  |  | Gispert et al., 2013; |
|  |  |  |  | Gupta et al., 1988; |
|  |  |  |  | Hu et al., 2019a; |
|  |  |  |  | Juma and Tabatai, 1988; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Kunito et al., 2001; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2021a; |
|  |  |  |  | Li et al., 2009; |
|  |  |  |  | Liu et al., 2008; |
|  |  |  |  | Martyniuk et al., 2019; |
|  |  |  |  | Masto et al., 2013; |
|  |  |  |  | Meli et al., 2002; |
|  |  |  |  | Mullen et al., 1998; |
|  |  |  |  | Nakas et al., 1987; |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  |  | Nedyalkova et al., 2020; |
|  |  |  |  | Nurulitaa et al., 2016; |
|  |  |  |  | Ortiz et al., 2020; |
|  |  |  |  | Pan et al., 2018; |
|  |  |  |  | Roldán et al., 2007; |
|  |  |  |  | Singh et al., 2012b; |
|  |  |  |  | Stege et al., 2009; |
|  |  |  |  | Sun et al., 2019; |
|  |  |  |  | Tripathi et al., 2007; |
|  |  |  |  | Trujillo-Narcía et al., 2019; |
|  |  |  |  | Turner and Haygarth, 2005; |
|  |  |  |  | Vanlalveni and Lalfakzuala, 2018; |
|  |  |  |  | Venkatesan et al., 2006; |
|  |  |  |  | Wang et al., 2017; |
|  |  |  |  | Wang et al., 2021c; |
|  |  |  |  | Woźniak et al., 2022; |
|  | ACP2 | Negative at pH >7 | 3 | Janes-Bassett et al., 2022; |
|  |  |  |  | Pokharel et al., 2020; |
|  |  |  |  | Sun et al., 2020; |
|  | ALP1 | Positive at pH >7 | 45 | Abdalla and Lager, 2009; |
|  |  |  |  | Acosta-Martínez and Tabatai, 2000; |
|  |  |  |  | Bachmann et al., 2014; |
|  |  |  |  | Basak et al., 2017; |
|  |  |  |  | Bera et al., 2016; |
|  |  |  |  | Bi et al., 2020; |
|  |  |  |  | Biswas et al., 2018; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Caballero Vanegas et al., 2018; |
|  |  |  |  | Carpenter-Boggs et al., 2003; |
|  |  |  |  | Chang et al., 2007; |
|  |  |  |  | Dick et al., 1988; |
|  |  |  |  | Dick et al., 2000; |
|  |  |  |  | Dinesh et al., 1998; |
|  |  |  |  | Firmano et al., 2021; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Graça et al., 2021; |
|  |  |  |  | Guo et al., 2009 |
|  |  |  |  | Gupta et al., 1988; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Kunito et al., 2001; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2017a; |
|  |  |  |  | Li et al., 2009; |
|  |  |  |  | Madejón et al., 2003; |
|  |  |  |  | Mandal et al., 2018; |
|  |  |  |  | Melero et al., 2008a |
|  |  |  |  | Melero et al., 2009; |
|  |  |  |  | Meli et al., 2002; |
|  |  |  |  | Monkiedje et al., 2006; |
|  |  |  |  | Nath et al., 2021; |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  |  | Rouydel et al., 2021; |
|  |  |  |  | Senwo et al., 2007 |
|  |  |  |  | Shi et al., 2020; |
|  |  |  |  | Siebielec et al., 2018; |
|  |  |  |  | Singh et al., 2012b; |
|  |  |  |  | Singh et al., 2020; |
|  |  |  |  | Stege et al., 2009; |
|  |  |  |  | Tavali et al., 2021; |
|  |  |  |  | Tripathi et al., 2007; |
|  |  |  |  | Truu et al., 2008; |
|  |  |  |  | Wang et al., 2022c; |
|  |  |  |  | Wojewódzki et al., 2022; |
|  |  |  |  | Yu et al., 2021 |
|  | ALP2 | Positive at pH >7 | 3 | Janes-Bassett et al., 2022; |
|  |  |  |  | Pokharel et al., 2020; |
|  |  |  |  | Sun et al., 2020; |
| Cation exchange capacity | ACP1 | Positive | 1 | Gonnety et al., 2012; |
|  |  | Negative | 1 | Senwo et al., 2007; |
|  | ALP1 | Positive | 1 | Gonnety et al., 2012; |
|  |  |  |  | Senwo et al., 2007; |
|  |  | Negative | 1 | Valarini et al., 2003; |
| Electrical conductivity | ACP1 | Positive | 3 | Arora et al., 2021; |
|  |  |  |  | Liu et al., 2008; |
|  |  |  |  | Venkatesan et al., 2006; |
|  | ALP1 | Positive | 7 | Al-Taweel et al., 2019; |
|  |  |  |  | Arora et al., 2021; |
|  |  |  |  | Guo et al., 2009; |
|  |  |  |  | Melero et al., 2008a; |
|  |  |  |  | Melero et al., 2009; |
|  |  |  |  | Monkiedje et al., 2006; |
|  |  |  |  | Singh et al., 2012b; |
| Chlorine anion content | ACP1 | Negative | 1 | Dinesh et al., 1995; |
| Carbonate content | ACP1 | Negative | 2 | Dick et al., 2000; |
|  |  |  |  | Siddaramappa et al., 1994; |
|  | ALP1 | Positive | 2 | Dick et al., 2000; |
|  |  |  |  | Mahmood et al., 2022; |
| Iron content | ACP1 | Positive | 1 | Maini et al., 2022; |
|  | ALP1 | Positive | 3 | Maini et al., 2022; |
|  |  |  |  | Senwo et al., 2007; |
|  |  |  |  | Yu et al., 2006; |
| Exchangeable aluminium content | ACP1 | Positive | 1 | Meena et al., 2021; |

*Table S4. Single studies of APase response relationships to levels of soil salinity.*

|  |  |  |  |
| --- | --- | --- | --- |
| **APase** | **Response relationship** | **Vote counting** | **Study** |
| ACP | Negative | 3 | Garcia and Hernández, 1996; |
|  |  |  | Rouydel et al., 2021; |
|  |  |  | Sadeghi and Taban, 2021; |
| ALP | Negative | 2 | Al-Taweel et al., 2019; |
|  |  |  | Fitriatin et al., 2018; |

*Table S5. Single and meta-analysis studies of APase response relationships to soil carbon content.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Soil carbon variable** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Soil organic carbon/matter | ACP1 | Positive | 53 | Acosta-Martínez et al., 2003b; |
|  |  |  | Acosta-Martínez et al., 2004; |
|  |  |  |  | Avila-Salem et al., 2020; |
|  |  |  |  | Babu et al., 2020; |
|  |  |  |  | ﻿Baligar et al., 2005; |
|  |  |  |  | Balota et al., 2011b; |
|  |  |  |  | Bobul'ská et al., 2015; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Butterly et al., 2011; |
|  |  |  |  | Chang et al., 2007; |
|  |  |  |  | Chellappa et al., 2021; |
|  |  |  |  | Chen et al., 2021c; |
|  |  |  |  | Choudhary et al., 2021; |
|  |  |  |  | D’Ascoli et al., 2006; |
|  |  |  |  | de Varennes and Torres, 2011; |
|  |  |  |  | Eivazi et al., 2003; |
|  |  |  |  | Evald et al., 2021; |
|  |  |  |  | Fernández-Calviño et al., 2010; |
|  |  |  |  | Gaind and Singh, 2016; |
|  |  |  |  | Green et al., 2007; |
|  |  |  |  | Hazarika et al., 2009; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2021a; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Mahajan et al., 2021; |
|  |  |  |  | Maini et al., 2022; |
|  |  |  |  | McCallister et al., 2002; |
|  |  |  |  | Monkiedje et al., 2006; |
|  |  |  |  | Mullen et al., 1998; |
|  |  |  |  | Omenda et al., 2019; |
|  |  |  |  | Pan et al., 2018; |
|  |  |  |  | Ramdas et al., 2016; |
|  |  |  |  | Rietz and Haynes, 2003; |
|  |  |  |  | Roy et al., 2019; |
|  |  |  |  | Sangma et al., 2016; |
|  |  |  |  | Šarapatka et al., 2004; |
|  |  |  |  | Sarkar et al., 2020; |
|  |  |  |  | Sharma et al., 2013a; |
|  |  |  |  | Sharma et al., 2019a; |
|  |  |  |  | Singh et al., 2018b; |
|  |  |  |  | Singh et al., 2021; |
|  |  |  |  | Siwik-Ziomek et al., 2014; |
|  |  |  |  | Soon et al., 2000; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Truu et al., 2008; |
|  |  |  |  | Tuti et al., 2020; |
|  |  |  |  | Venkatesan et al., 2006; |
|  |  |  |  | Wang et al., 2011b; |
|  |  |  |  | Wei et al., 2017; |
|  |  |  |  | Yu et al., 2006; |
|  |  |  |  | Zuazo et al., 2020; |
|  | ACP2 | Positive | 1 | Sun et al., 2020; |
|  | ALP1 | Positive | 47 | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Acosta-Martínez et al., 2004; |
|  |  |  |  | Arora et al., 2021; |
|  |  |  |  | Bhattachayya et al., 2008; |
|  |  |  |  | Blaise and Rao, 2004; |
|  |  |  |  | Bobul'ská et al., 2015; |
|  |  |  |  | Borase et al., 2020; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Cao et al., 2022; |
|  |  |  |  | Cattaneo et al., 2014; |
|  |  |  |  | Chang et al., 2007; |
|  |  |  |  | Chocano et al., 2016; |
|  |  |  |  | Choudhary et al., 2018c; |
|  |  |  |  | Choudhary et al., 2021; |
|  |  |  |  | Cui et al., 2015; |
|  |  |  |  | Eivazi et al., 2003; |
|  |  |  |  | Gaind and Singh, 2016; |
|  |  |  |  | Gangwar et al., 2021; |
|  |  |  |  | Ghosh et al., 2019; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2017b; |
|  |  |  |  | Liu et al., 2017; |
|  |  |  |  | Łukowski and Dec, 2018; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Madejón et al., 2007; |
|  |  |  |  | Maini et al., 2022; |
|  |  |  |  | ﻿Melero et al., 2006; |
|  |  |  |  | Mullen et al., 1998; |
|  |  |  |  | Rietz and Haynes, 2003; |
|  |  |  |  | Roy et al., 2019; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Sharma et al., 2015; |
|  |  |  |  | Sharma et al., 2019a; |
|  |  |  |  | Shi et al., 2020; |
|  |  |  |  | Singh et al., 2018b; |
|  |  |  |  | Singh et al., 2021; |
|  |  |  |  | Siwik-Ziomek et al., 2014; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Truu et al., 2008; |
|  |  |  |  | Tuti et al., 2020; |
|  |  |  |  | Vekemans et al., 1989; |
|  |  |  |  | Verma et al., 2016a; |
|  |  |  |  | Wang et al., 2011b; |
|  |  |  |  | Yu et al., 2006; |
|  |  |  |  | Yu et al., 2021; |
|  |  |  |  | Zhao et al., 2009; |
|  | ALP2 | Positive | 1 | Pokharel et al., 2020; |
| Total organic carbon | ACP1 | Positive | 10 | Borase et al., 2021; |
|  |  |  |  | da Silva Xavier et al., 2020; |
|  |  |  |  | Franco-Otero et al., 2012; |
|  |  |  |  | Futa et al., 2021; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Kobierski and Lemanowicz, 2016; |
|  |  |  |  | Kobierski et al., 2017; |
|  |  |  |  | Liu et al., 2008; |
|  |  |  |  | Sarkar et al., 2009; |
|  |  |  |  | Tiecher et al., 2017; |
|  |  | Negative | 1 | Wojewódzki et al., 2022; |
|  | ALP1 | Positive | 11 | Bera et al., 2016; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Futa et al., 2021; |
|  |  |  |  | Guo et al., 2009; |
|  |  |  |  | Kobierski and Lemanowicz, 2016; |
|  |  |  |  | Melero et al., 2007b; |
|  |  |  |  | Melero et al., 2008a; |
|  |  |  |  | Melero et al., 2009; |
|  |  |  |  | Melero Sánchez et al., 2008; |
|  |  |  |  | Sarkar et al., 2009; |
|  |  |  |  | Sharma et al., 2019b; |
| Dissolved organic carbon | ACP1 | Positive | 3 | Basak and Gajbhiye, 2018; |
|  |  |  |  | Franco-Otero et al., 2012; |
|  |  |  |  | Hazarika et al., 2009; |
|  | ALP1 | Positive | 5 | Basak and Gajbhiye, 2018; |
|  |  |  |  | Calvarro et al., 2014; |
|  |  |  |  | Madejón et al., 2007; |
|  |  |  |  | Sharma et al., 2019b; |
|  |  |  |  | Wojewódzki et al., 2022; |

*Table S6. Single and meta-analysis studies of APase response relationships to soil content of nitrogen forms and soil carbon:nitrogen ratios.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Nitrogen form/ratio** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Nitrate nitrogen | ACP1 | Positive | 1 | Roy et al., 2019; |
|  |  | Negative | 2 | Schaller K., 2003; |
|  |  |  |  | Wang et al., 2021c; |
|  | ALP1 | Positive | 1 | Roy et al., 2019; |
|  |  | Negative | 1 | Verma et al., 2016a; |
|  |  | None | 2 | Adrover et al., 2017; |
|  |  |  |  | Wang et al., 2022b; |
| Ammonium nitrogen | ACP1 | Positive | 2 | Liu et al., 2008; |
|  |  |  | Roy et al., 2019; |
|  |  | None | 1 | Wang et al., 2013a; |
|  | ALP1 | Positive | 2 | Roy et al., 2019; |
|  |  |  |  | Monkiedje et al., 2006; |
|  |  | None | 1 | Wang et al., 2022a; |
| Total nitrogen  (Kjeldahl method) | ACP1 | Positive | 15 | ﻿Baligar et al., 2005; |
|  |  |  | Chen et al., 2021b; |
|  |  |  |  | Chen et al., 2021a; |
|  |  |  |  | Fernández-Calviño et al., 2010; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Green et al., 2007; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2021a; |
|  |  |  |  | Mandal et al., 2007; |
|  |  |  |  | Qaswar et al., 2019; |
|  |  |  |  | Sudhakaran et al., 2019; |
|  |  |  |  | Tamilselvi et al., 2015; |
|  |  |  |  | Turner and Haygarth, 2005; |
|  |  |  |  | Wang et al., 2011b; |
|  |  | Negative | 1 | Wojewódzki et al., 2022; |
|  | ACP2 | Positive | 1 | Sun et al., 2020; |
|  | ALP1 | Positive | 18 | Acosta-Martínez et al., 2004; |
|  |  |  |  | Cattaneo et al., 2014; |
|  |  |  |  | Dinesh et al., 1998; |
|  |  |  |  | Gelsomino et al., 2011; |
|  |  |  |  | Guo et al., 2009; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2017a; |
|  |  |  |  | Liu et al., 2017; |
|  |  |  |  | Mandal et al., 2007; |
|  |  |  |  | Melero et al., 2007b; |
|  |  |  |  | Melero Sánchez et al., 2008; |
|  |  |  |  | Shi et al., 2020; |
|  |  |  |  | Tan et al., 2014; |
|  |  |  |  | Truu et al., 2008; |
|  |  |  |  | Vekemans et al., 1989; |
|  |  |  |  | Wang et al., 2011b; |
|  |  |  |  | Wojewódzki et al., 2022; |
| Soil carbon:nitrogen ratio | ACP1 | Positive | 1 | Liu et al., 2008; |
|  | ALP1 | Positive | 1 | Singh and Ghoshal, 2013; |

*Table S7. Single and meta-analysis studies of APase response relationships to soil content of phosphorus forms and carbon:phosphorus ratios.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phosphorus form/ratio** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Labile inorganic phosphorus (Pi) | ACP1 | Negative | 10 | Alves et al., 2021; |
|  |  |  | Arruda et al., 2018; |
|  |  |  |  | Castillo et al., 2017; |
|  |  |  |  | Gao et al., 2016; |
|  |  |  |  | Ohm et al., 2017; |
|  |  |  |  | Romanya et al., 2017; |
|  |  |  |  | Schoebitz et al., 2020; |
|  |  |  |  | Simanca Fontalvo and Cuervo Andrade, 2018; |
|  |  |  |  | Tarafdar and Claassen, 1988; |
|  |  |  |  | Teng et al., 2013; |
|  | ALP1 | Negative | 5 | Fereidooni et al., 2013; |
|  |  |  |  | Mahmood et al., 2022; |
|  |  |  |  | Niewiadomska et al., 2020a; |
|  |  |  |  | Recena et al., 2015; |
|  |  |  |  | Simanca Fontalvo and Cuervo Andrade, 2018; |
| Soil solution phosphorus | ACP1 | Positive | 23 | Arora et al., 2021; |
|  |  |  |  | Atoloye et al., 2021; |
|  |  |  |  | Babu et al., 2020; |
|  |  |  |  | Futa et al., 2021; |
|  |  |  |  | Guo et al., 2009; |
|  |  |  |  | Kamh et al., 1999; |
|  |  |  |  | Kobierski and Lemanowicz, 2016; |
|  |  |  |  | Kobierski et al., 2017; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Li et al., 2018a; |
|  |  |  |  | Liu et al., 2008; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Mahajan et al., 2021; |
|  |  |  |  | Maini et al., 2022; |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  |  | Ortiz et al., 2020; |
|  |  |  |  | Qaswar et al., 2019; |
|  |  |  |  | Sharma et al., 2019a; |
|  |  |  |  | Sharpley et al., 1995; |
|  |  |  |  | Singh et al., 2012a; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Yuan et al., 2022; |
|  |  |  |  | Zhong et al., 2007; |
|  |  | Negative | 1 | Saha et al., 2008a; |
|  |  | None | 3 | Koczorski et al., 2021; |
|  |  |  |  | Waldrop et al., 2000; |
|  |  |  |  | Wojewódzki et al., 2022; |
|  | ALP1 | Positive | 16 | Arora et al., 2021; |
|  |  |  |  | Futa et al., 2021; |
|  |  |  |  | Garg and Bahl, 2008; |
|  |  |  |  | Guo et al., 2021; |
|  |  |  |  | Kobierski and Lemanowicz, 2016; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Liu et al., 2017; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Maini et al., 2022; |
|  |  |  |  | Sharma et al., 2019a; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Verma et al., 2016a; |
|  |  |  |  | Wang et al., 2021a; |
|  |  |  |  | Wang et al., 2021b; |
|  |  |  |  | Wojewódzki et al., 2022; |
|  |  |  |  | Zhao et al., 2009; |
|  |  | Negative | 2 | Madejón et al., 2003; |
|  |  |  |  | Saha et al., 2008a; |
|  |  | None | 2 | Koczorski et al., 2021; |
|  |  |  |  | Wang et al., 2022a; |
| Olsen phosphorus | ACP1 | Positive | 7 | Basak et al., 2017; |
|  |  |  | Basak and Gajbhiye, 2018; |
|  |  |  |  | Moharana et al., 2022; |
|  |  |  |  | Roy et al., 2019; |
|  |  |  |  | Singh et al., 2018b; |
|  |  |  |  | Yin et al., 2021; |
|  |  |  |  | Zhang et al., 2019a; |
|  | ACP1 | Negative | 1 | Wang et al., 2021c; |
|  | ACP2 | Negative | 1 | Sun et al., 2020; |
|  | ALP1 | Positive | 8 | Atoloye et al., 2021; |
|  |  |  |  | Basak and Gajbhiye, 2018; |
|  |  |  |  | Melero et al., 2007b; |
|  |  |  |  | Melero Sánchez et al., 2008; |
|  |  |  |  | Moharana et al., 2022; |
|  |  |  |  | Roy et al., 2019; |
|  |  |  |  | Sharma et al., 2015; |
|  |  |  |  | Singh et al., 2018b; |
|  |  | Negative | 4 | Fraser et al., 2015; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Soni et al., 2021; |
|  |  |  |  | Yu et al., 2006; |
| Organic phosphorus | ACP1 | Positive | 6 | Moharana et al., 2022; |
|  |  |  |  | Silva et al., 2015; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Turner and Haygarth, 2005; |
|  |  |  |  | Wang et al., 2011c; |
|  |  |  |  | Wei et al., 2021; |
|  | ALP1 | Positive | 5 | Dey et al., 2019; |
|  |  |  |  | Guo et al., 2009; |
|  |  |  |  | Moharana et al., 2022; |
|  |  |  |  | Recena et al., 2015; |
|  |  |  |  | Tarafdar et al., 1989; |
| Labile organic phosphorus (Po) | ACP1 | Negative | 3 | Kamh et al., 1999; |
|  |  |  | Wang et al., 2022b; |
|  |  |  |  | Wu et al., 2012; |
|  | ACP2 | Negative | 1 | Sun et al., 2020; |
|  | ALP1 | Negative | 1 | de Santiago-Martín et al., 2013; |
| Soil carbon: phosphorus ratio | ACP1 | Positive | 1 | Li et al., 2021a; |

*Table S8. Single studies of APase response relationships to soil available potassium content.*

|  |  |  |  |
| --- | --- | --- | --- |
| **APase** | **Response relationship** | **Vote counting** | **Study** |
| ACP | Positive | 6 | Arora et al., 2021; |
|  |  |  | Koczorski et al., 2021; |
|  |  |  | Laxminarayana K., 2017; |
|  |  |  | Mahajan et al., 2021; |
|  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  | Venkatesan et al., 2006; |
| ALP | Positive | 6 | Arora et al., 2021; |
|  |  |  | Koczorski et al., 2021; |
|  |  |  | Laxminarayana K., 2017; |
|  |  |  | Roy et al., 2019; |
|  |  |  | Sharma et al., 2019a; |
|  |  |  | Tan et al., 2014; |

*Table S9. Single and meta-analysis studies of APase response relationships to land use change.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land use** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Ungrazed grassland, meadow, pasture | ACP1 | Positive | 25 | Acosta-Martínez et al., 2008; |
|  |  |  |  | Avila-Salem et al., 2020; |
|  |  |  |  | Carlos et al., 2022; |
|  |  |  |  | Chen et al., 2004; |
|  |  |  |  | Damian et al., 2021; |
|  |  |  |  | Gonnety et al., 2012; |
|  |  |  |  | Graça et al., 2021; |
|  |  |  |  | Izquierdo et al., 2003; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Kremer and Li, 2003; |
|  |  |  |  | Lebrun et al., 2012; |
|  |  |  |  | Li et al., 2017b; |
|  |  |  |  | Notaro et al., 2018; |
|  |  |  |  | Ohm et al., 2017; |
|  |  |  |  | Pan et al., 2018; |
|  |  |  |  | Pankhurst et al., 1995; |
|  |  |  |  | Paz-Ferreiro et al., 2009; |
|  |  |  |  | Raiesi F., 2007 |
|  |  |  |  | Reardon et al., 2016; |
|  |  |  |  | ﻿Šarapatka et al., 2004; |
|  |  |  |  | Serri et al., 2018; |
|  |  |  |  | Shi et al., 2013; |
|  |  |  |  | Silvestro et al., 2017; |
|  |  |  |  | Tiecher et al., 2012; |
|  |  |  |  | Vinhal-Freitas et al., 2017; |
|  | ALP1 | Positive | 13 | Acosta-Martínez et al., 2008; |
|  |  |  |  | Cattaneo et al., 2014; |
|  |  |  |  | Cui et al., 2019; |
|  |  |  |  | Dong et al., 2016; |
|  |  |  |  | Gonnety et al., 2012; |
|  |  |  |  | Graça et al., 2021; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Kremer and Li, 2003; |
|  |  |  |  | Lebrun et al., 2012; |
|  |  |  |  | Notaro et al., 2018; |
|  |  |  |  | Ohm et al., 2017; |
|  |  |  |  | Raiesi F., 2007; |
|  |  |  |  | Saviozzi et al., 2001; |
| Revegetation |  |  |  |  |
| Natural vegetation | ACP1 | Positive | 1 | Aon and Colaneri, 2001; |
| Non cultivated | ACP1 | Positive | 1 | Dick et al., 1994 |
| Recolonization trees | ACP1 | Positive | 1 | Garcia et al., 1997; |
| Reconstruction prairie | ACP1 | Positive | 1 | García-Orenes et al., 2010; |
| Spontaneous recovery | ACP1 | Positive | 3 | Li et al., 2021a; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Sciubba et al., 2021; |
| Plant invasion | ACP, ALP2 | Positive | 1 | Margalef et al., 2021; |
| Forest clearance for cropland | ACP1 | Negative | 11 | Barcelos Martins et al., 2019; |
|  |  |  |  | Caravaca et al., 2002; |
|  |  |  |  | de Oliveira Silva et al., 2019; |
|  |  |  |  | Dormaar and Willms, 2000; |
|  |  |  |  | Garcia et al., 1997; |
|  |  |  |  | Guo et al., 2009 |
|  |  |  |  | Hernández-Vigoa et al., 2018 |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Leirós et al., 1999; |
|  |  |  |  | Raiesi F., 2007; |
|  |  |  |  | Serri et al., 2018; |
|  | ALP1 | Negative | 3 | Guo et al., 2009; |
|  |  |  |  | Katsalirou et al., 2016; |
|  |  |  |  | Raiesi F., 2007 |
| Afforestation | ACP1 | Positive | 10 | Arora et al., 2021; |
|  |  |  |  | Brackin et al., 2014; |
|  |  |  |  | Figueira da Silva et al., 2020; |
|  |  |  |  | Garcia et al., 1997; |
|  |  |  |  | Kooch et al., 2019; |
|  |  |  |  | Li et al., 2021a; |
|  |  |  |  | Martins Sousa et al., 2020; |
|  |  |  |  | Nurulitaa et al., 2016; |
|  |  |  |  | Singh et al., 2012a; |
|  |  |  |  | Ventura et al., 2021; |
|  | ALP1 | Positive | 7 | Arora et al., 2021; |
|  |  |  |  | Cui et al., 2019; |
|  |  |  |  | Dilly O., 1999; |
|  |  |  |  | Lungmuana et al., 2019; |
|  |  |  |  | Neha et al., 2020; |
|  |  |  |  | Tarafdar et al., 1989; |
|  |  |  |  | Zhang et al., 2015; |

*Table S10. Single studies of APase response relationships to crop rotation composition and cover cropping.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Crop rotation type/property** | **APase** | **Response relationship** | **Vote counting** | **Study** |
| Crop rotation | ACP | Positive | 14 | Alvey et al., 2001; |
|  |  |  |  | Chen et al., 2018; |
|  |  |  |  | Eichler-Löbermann et al., 2021; |
|  |  |  |  | Ferreras et al., 2009; |
|  |  |  |  | He et al., 2010; |
|  |  |  |  | Inal et al., 2007; |
|  |  |  |  | Jain et al., 2018; |
|  |  |  |  | Koczorski et al., 2021; |
|  |  |  |  | Nayyar et al., 2009 |
|  |  |  |  | Qaswar et al., 2019; |
|  |  |  |  | Redel et al., 2011; |
|  |  |  |  | Siwik-Ziomek et al., 2014; |
|  |  |  |  | Woźniak and Kawecka-Radomska, 2016; |
|  |  |  |  | Yu et al., 2021; |
|  | ALP | Positive | 13 | Acosta-Martínez et al., 2003a; |
|  |  |  |  | Acosta-Martínez et al., 2011a; |
|  |  |  |  | Alvey et al., 2001; |
|  |  |  |  | Borase et al., 2020; |
|  |  |  |  | Eichler-Löbermann et al., 2021; |
|  |  |  |  | Gou et al., 2020; |
|  |  |  |  | Habig and Swanepoel, 2018; |
|  |  |  |  | He et al., 2010 |
|  |  |  |  | Jain et al., 2018; |
|  |  |  |  | Koczorski et al., 2021; |
|  |  |  |  | Saad et al., 2018; |
|  |  |  |  | Siwik-Ziomek et al., 2014; |
|  |  |  |  | Yu et al., 2021; |
| Cereal-legumes | ACP | Positive | 2 | Eichler-Löbermann et al., 2021; |
|  |  |  |  | Nath et al., 2021; |
|  | ALP | Positive | 2 | Eichler-Löbermann et al., 2021; |
|  |  |  |  | Nath et al., 2021; |
| Cereal-based | ACP | Positive | 4 | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Chen et al., 2021a; |
|  |  |  |  | Datta et al., 2021; |
|  |  |  |  | Dick et al., 1988; |
|  | ALP | Positive | 7 | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Choudharyet al., 2018b; |
|  |  |  |  | Datta et al., 2021; |
|  |  |  |  | Dick et al., 1988; |
|  |  |  |  | Gajda and Martyniuk, 2005; |
|  |  |  |  | Wick et al., 1998; |
|  |  |  |  | Zhang et al., 2018; |
| Cover crops | ACP | Positive | 13 | Adetunji et al., 2021; |
|  |  |  |  | Boccolini et al., 2019; |
|  |  |  |  | Chavarría et al., 2016; |
|  |  |  |  | Cui et al., 2015; |
|  |  |  |  | de Castro Lopes et al., 2021; |
|  |  |  |  | Feng et al., 2021; |
|  |  |  |  | Mullen et al., 1998; |
|  |  |  |  | Pérez Brandan et al., 2017; |
|  |  |  |  | Ramos et al., 2011; |
|  |  |  |  | Ramos et al., 2010; |
|  |  |  |  | Stegarescu et al., 2021; |
|  |  |  |  | Takeda et al., 2009; |
|  |  |  |  | Ventura et al., 2021; |
|  | ALP | Positive | 8 | Cui et al., 2015; |
|  |  |  |  | Feng et al., 2021; |
|  |  |  |  | Hai-Ming et al., 2014; |
|  |  |  |  | Melero et al., 2007a; |
|  |  |  |  | Mullen et al., 1998; |
|  |  |  |  | Niewiadomska et al., 2020b; |
|  |  |  |  | Thapa et al., 2021; |
|  |  |  |  | Wang et al., 2021b; |
| Intercropping | ACP | Positive | 4 | Balota et al., 2010; |
|  |  |  |  | Gunes et al., 2007; |
|  |  |  |  | Koczorski et al., 2021; |
|  |  |  |  | Roohi et al., 2020; |
|  | ALP | Positive | 3 | Koczorski et al., 2021; |
|  |  |  |  | Roohi et al., 2020; |
|  |  |  |  | Li et al., 2021b; |
| Intercropping+fertilization | ACP | Positive | 1 | Rezaei-Chiyaneh et al., 2021; |
|  | ALP | Positive | 3 | Pittarello et al., 2021; |
|  |  |  |  | Rezaei-Chiyaneh et al., 2021; |
|  |  |  |  | Wang et al., 2014b; |
| Intercropping with legumes | ACP | Positive | 2 | Balota et al., 2010; |
|  |  |  |  | Lo Presti et al., 2021; |
| Wheat vs maize/rice | ACP | Positive | 2 | Furtak et al., 2017; |
|  |  |  |  | Masto et al., 2006; |
|  | ALP | Positive | 3 | Furtak et al., 2017; |
|  |  |  |  | Masto et al., 2006; |
|  |  |  |  | Tao et al., 2009; |
| Legumes vs wheat/rice | ACP | Positive | 11 | Ansari et al., 2021; |
|  |  |  |  | Aparna et al., 2016; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Gunes et al., 2007 |
|  |  |  |  | Kumar et al., 2017; |
|  |  |  |  | Li et al., 2021b; |
|  |  |  |  | Lo Presti et al., 2021; |
|  |  |  |  | Nuruzzaman et al., 2006; |
|  |  |  |  | Ohm et al., 2017; |
|  |  |  |  | Raghurama et al., 2022; |
|  |  |  |  | Singh et al., 2021; |
|  | ALP | Positive | 7 | Acosta-Martínez et al., 2004; |
|  |  |  |  | Aparna et al., 2016; |
|  |  |  |  | Borase et al., 2021; |
|  |  |  |  | Datta et al., 2021; |
|  |  |  |  | Kumar et al., 2017; |
|  |  |  |  | Singh et al., 2021; |
|  |  |  |  | Yu et al., 2021; |
| Horticulture vs maize | ACP | Positive | 4 | Avila-Salem et al., 2020; |
|  |  |  |  | Lago et al., 2019; |
|  |  |  |  | Maini et al., 2022; |
|  |  |  |  | ﻿Monkiedje et al., 2006; |
|  | ALP | Positive | 2 | Maini et al., 2022; |
|  |  |  |  | ﻿Monkiedje et al., 2006; |
| Barley vs horticulture | ACP | Positive | 1 | Moreno et al., 1998; |
| Monoculture maize vs others | ACP | Positive | 8 | Bossio et al., 2005; |
|  |  |  |  | Dora et al., 2006; |
|  |  |  |  | Fialho et al., 2008; |
|  |  |  |  | Mankolo et al., 2006; |
|  |  |  |  | Roohi et al., 2020; |
|  |  |  |  | Savin et al., 2009; |
|  |  |  |  | Serafim et al., 2019; |
|  |  |  |  | Wang et al., 2017; |
|  | ALP | Positive | 4 | Bossio et al., 2005; |
|  |  |  |  | Dora et al., 2006; |
|  |  |  |  | Roohi et al., 2020; |
|  |  |  |  | Savin et al., 2009; |
| Monoculture lupine vs others | ACP | Positive | 4 | Lo Presti et al., 2021; |
|  |  |  |  | Redel et al., 2007; |
|  |  |  |  | Schoebitz et al., 2020; |
|  |  |  |  | Touhami et al., 2021; |
|  | ALP | Positive | 2 | Touhami et al., 2021; |
|  |  |  |  | Wyszkowska et al., 2019; |
| Monoculture sorghum vs others | ACP | Positive | 2 | Alvey et al., 2001; |
|  |  |  |  | Neal et al., 2021; |
|  | ALP | Positive | 2 | Dou et al., 2016; |
|  |  |  |  | Neal et al., 2021; |
| Monoculture transgenic cotton vs cotton | ACP | Positive | 2 | Beura and Rakshit, 2013; |
|  |  |  |  | Sarkar et al., 2009; |
|  | ALP | Positive | 3 | Beura and Rakshit, 2013; |
|  |  |  |  | Mandal et al., 2018; |
|  |  |  |  | Sarkar et al., 2009; |
| Monoculture transgenic rice vs rice | ACP | None | 2 | Zhaolei et al., 2017; |
|  |  |  |  | Wei et al., 2012 |

*Table S11. Single studies of response relationships of APase to tillage practices.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tillage practice** | **APase** | **Response relationship** | **Vote counting** | **Study** |
| Conventional tillage vs others | ACP | Positive | 4 | Acosta-Martínez et al., 2003b; |
|  |  |  |  | de Varennes and Torres, 2011; |
|  |  |  |  | Niewiadomska et al., 2016; |
|  |  |  |  | Woźniak, A., 2019; |
|  |  | Negative | 8 | ﻿Balota et al., 2004; |
|  |  |  |  | Balota et al., 2011a; |
|  |  |  |  | Bini et al., 2014; |
|  |  |  |  | Carter et al., 2007 |
|  |  |  |  | Farhangi-Abriz et al., 2021; |
|  |  |  |  | Jaskulska R., 2020a; |
|  |  |  |  | Peixoto et al., 2010 |
|  |  |  |  | Swędrzyńska et al., 2013; |
|  | ALP | Positive | 4 | Acosta-Martínez et al., 2003a; |
|  |  |  |  | Acosta-Martínez et al., 2003b; |
|  |  |  |  | Niewiadomska et al., 2016; |
|  |  |  |  | Soni et al., 2021; |
|  |  | Negative | 3 | ﻿Balota et al., 2004; |
|  |  |  |  | Jaskulska R., 2020a; |
|  |  |  |  | Niewiadomska et al., 2020b; |
| Reduced tillage vs conventional tillage | ACP | Positive | 5 | Farhangi-Abriz et al., 2021; |
|  |  |  |  | Gajda and Przewłoka, 2012; |
|  |  |  |  | Jaskulska R., 2020a; |
|  |  |  |  | Ventura et al., 2021; |
|  |  |  |  | Woźniak and Kawecka-Radomska, 2016; |
|  | ALP | Positive | 2 | Madejón et al., 2007 |
|  |  |  |  | Zibilske and Bradford, 2003; |
| No till vs others | ACP | Positive | 24 | ﻿Balota et al., 2004; |
|  |  |  |  | Balota et al., 2011a; |
|  |  |  |  | Barcelos Martins et al., 2019; |
|  |  |  |  | Caballero Vanegas et al., 2018; |
|  |  |  |  | Campbell et al., 1989; |
|  |  |  |  | Chellappa et al., 2021; |
|  |  |  |  | Eivazi et al., 2003; |
|  |  |  |  | Green et al., 2007; |
|  |  |  |  | Hatti et al., 2018; |
|  |  |  |  | Hazarika et al., 2009; |
|  |  |  |  | Hu et al., 2019b; |
|  |  |  |  | Kumar et al., 2017; |
|  |  |  |  | Mina et al., 2008 |
|  |  |  |  | Nath et al., 2017; |
|  |  |  |  | Omidi et al., 2008 |
|  |  |  |  | Peixoto et al., 2020 |
|  |  |  |  | Redel et al., 2011; |
|  |  |  |  | Roldán et al., 2007; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Silvestro et al., 2017; |
|  |  |  |  | Ventura et al., 2021; |
|  |  |  |  | Wang et al., 2011a; |
|  |  |  |  | Wang et al., 2011b; |
|  |  |  |  | Yang et al., 2019; |
|  | ALP | Positive | 21 | Acosta-Martinez et al., 2011a; |
|  |  |  |  | ﻿Balota et al., 2004; |
|  |  |  |  | Bergstrom et al., 1998b; |
|  |  |  |  | Caballero Vanegas et al., 2018; |
|  |  |  |  | Carpenter-Boggs et al., 2003; |
|  |  |  |  | Choudhary et al., 2018a; |
|  |  |  |  | Habig and Swanepoel, 2018; |
|  |  |  |  | Kumar et al., 2017; |
|  |  |  |  | Melero et al., 2011; |
|  |  |  |  | Mina et al., 2008 |
|  |  |  |  | Naragund et al., 2020; |
|  |  |  |  | Omidi et al., 2008 |
|  |  |  |  | Parihar et al., 2016; |
|  |  |  |  | Parihar et al., 2016; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Shahane et al., 2020; |
|  |  |  |  | Singh et al., 2022; |
|  |  |  |  | Wang et al., 2011b; |
|  |  |  |  | Wei et al., 2014b; |
|  |  |  |  | Xomphoutheb et al., 2020; |
|  |  |  |  | Yang et al., 2019; |
| No till + residue retention vs others | ACP | Positive | 9 | Ahmed et al., 2019; |
|  |  |  |  | Bini et al., 2014; |
|  |  |  |  | Chellappa et al., 2021; |
|  |  |  |  | Malobane et al., 2020; |
|  |  |  |  | Rabary et al., 2008 |
|  |  |  |  | Redel et al., 2007; |
|  |  |  |  | Redel et al., 2011; |
|  |  |  |  | Wang et al., 2011a; |
|  |  |  |  | Cao et al., 2021; |
|  | ALP | Positive | 1 | Wei et al., 2014a; |
| No till with depth vs others | ACP | Positive | 5 | Dick W.A., 1984; |
|  |  |  |  | Doran J.W., 1980; |
|  |  |  |  | Green et al., 2007; |
|  |  |  |  | Kumar et al., 2017; |
|  |  |  |  | Wang et al., 2011a; |
|  | ALP | Positive | 6 | Angers et al., 1993; |
|  |  |  |  | Dick W.A., 1984; |
|  |  |  |  | Kharia et al., 2017; |
|  |  |  |  | Kumar et al., 2017; |
|  |  |  |  | Parihar et al., 2020; |
|  |  |  |  | Shi et al., 2012; |

*Table S12. Single and meta-analysis studies of APase response relationships to types of inorganic and organic fertilization and rates.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Fertilization type** | | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Liming | ACP1 | Positive | 3 | Bardgett and Leemans, 1995; |
|  |  |  |  | Meena et al., 2021; |
|  |  |  |  | Shi et al., 2019a; |
|  |  | Negative | 2 | Makoi et al., 2010 |
|  |  |  |  | Siddaramappa et al., 1994; |
|  | ALP1 | Positive | 3 | Acosta-Martínez and Tabatai, 2000; |
|  |  |  |  | Firmano et al., 2021; |
|  |  |  |  | Lalande et al., 2009; |
|  |  | Negative | 1 | Makoi et al., 2010 |
| Inorganic fertilizer (general) | | ACP1 | Positive | 13 | Ajwaa et al., 1999; |
|  | |  |  |  | Bardgett and Leemans, 1995; |
|  | |  |  |  | Bi et al., 2018; |
|  | |  |  |  | Bi et al., 2020; |
|  | |  |  |  | Choudhary et al., 2021; |
|  | |  |  |  | de Castro Lopes et al., 2013; |
|  | |  |  |  | Futa et al., 2021; |
|  | |  |  |  | Gaind and Singh, 2016; |
|  | |  |  |  | Damian et al., 2021; |
|  | |  |  |  | Ning et al., 2017; |
|  | |  |  |  | Prasanthi et al., 2019; |
|  | |  |  |  | Rezaei-Chiyaneh et al., 2021; |
|  | |  |  |  | Verdenelli et al., 2013; |
|  | |  | Negative | 1 | Aparnad et al., 2016; |
|  | | ALP1 | Positive | 16 | Ajwaa et al., 1999; |
|  | |  |  |  | Aparna et al., 2016; |
|  | |  |  |  | Bi et al., 2018; |
|  | |  |  |  | Bi et al., 2020 |
|  | |  |  |  | Biswas et al., 2021; |
|  | |  |  |  | Choudhary et al., 2021; |
|  | |  |  |  | Dhull et al., 2004; |
|  | |  |  |  | Futa et al., 2021; |
|  | |  |  |  | Goyal et al., 1999; |
|  | |  |  |  | Jain et al., 2018; |
|  | |  |  |  | Joshi et al., 2021; |
|  | |  |  |  | Kumar et al., 2021b; |
|  | |  |  |  | Liu et al., 2010; |
|  | |  |  |  | Manna et al., 2005; |
|  | |  |  |  | Prasanthi et al., 2019; |
|  | |  |  |  | Rezaei-Chiyaneh et al., 2021; |
|  | |  | Negative | 1 | Wang et al., 2022a; |
|  | | ACP, ALP2 | Positive | 1 | Miao et al., 2019; |
| Inorganic nitrogen | | ACP1 | Positive | 8 | Bardgett and Leemans,1995; |
|  | |  |  |  | Dick et al., 1988; |
|  | |  |  |  | Guan et al., 2011; |
|  | |  |  |  | Johnson et al., 1998; |
|  | |  |  |  | Kohler et al., 2007; |
|  | |  |  |  | Menge and Field, 2007; |
|  | |  |  |  | Sarma and Gogoi, 2017; |
|  | |  |  |  | Siwik-Ziomek et al., 2014; |
|  | |  | Negative | 8 | Arruda et al., 2018; |
|  | |  |  |  | Chen et al., 2021a; |
|  | |  |  |  | Koper and Lemanowicz, 2008; |
|  | |  |  |  | Mullen et al., 1998; |
|  | |  |  |  | Rakshit et al., 2016; |
|  | |  |  |  | Siwik-Ziomek et al., 2014; |
|  | |  |  |  | Sun et al., 2020; |
|  | |  |  |  | Wang et al., 2021c; |
|  | | ACP2 | Positive | 1 | Jian et al., 2016; |
|  | | ALP1 | Positive | 2 | Liu et al., 2017; |
|  | |  |  |  | Siwik-Ziomek et al., 2014; |
|  | |  | Negative | 4 | Manna et al., 2005; |
|  | |  |  |  | Moreno-Cornejo et al., 2017; |
|  | |  |  |  | Rakshit et al., 2016; |
|  | |  |  |  | Siwik-Ziomek et al., 2014; |
|  | | ACP, ALP2 | Positive | 2 | Margalef et al., 2021; |
|  | |  |  |  | Marklein and Houlton, 2012; |
| Inorganic phosphorus | | ACP1 | Negative | 8 | de Castro Lopes et al., 2013; |
|  | |  |  |  | Gispert et al., 2013; |
|  | |  |  |  | Khandare et al., 2020; |
|  | |  |  |  | Li et al., 2021a; |
|  | |  |  |  | Liang and Elsgaard, 2021; |
|  | |  |  |  | Lo Presti et al., 2021; |
|  | |  |  |  | Silva et al., 2015; |
|  | |  |  |  | Wang et al., 2021c; |
|  | |  | None | 3 | Guan et al., 2013; |
|  | |  |  |  | Radersma and Grierson, 2004; |
|  | |  |  |  | Randall et al., 2020; |
|  | | ALP1 | Negative | 2 | Khandare et al., 2020; |
|  | |  |  |  | Svensson et al., 2001; |
|  | |  | None | 4 | Emami et al., 2022; |
|  | |  |  |  | Shi et al., 2012; |
|  | |  |  |  | Shi et al., 2020; |
|  | |  |  |  | Trabelsi et al., 2017; |
|  | | ACP, ALP2 | Negative | 2 | Margalef et al., 2021; |
|  | |  |  |  | Marklein and Houlton, 2012; |
|  | |  | None | 1 | Janes-Bassett et al., 2022; |
| Organic fertilizers | | ACP1 | Positive | 39 | Atoloye et al., 2021; |
|  | |  |  |  | Banik et al., 2006; |
|  | |  |  |  | Basak et al., 2017; |
|  | |  |  |  | Bobul'ská et al., 2015; |
|  | |  |  |  | Caballero Vanegas et al., 2018; |
|  | |  |  |  | Carricondo-Martínez et al., 2022; |
|  | |  |  |  | Chang et al., 2007; |
|  | |  |  |  | Chatterjee et al., 2021; |
|  | |  |  |  | Chen et al., 2003; |
|  | |  |  |  | Chen et al., 2021a; |
|  | |  |  |  | Cicatelli et al., 2014; |
|  | |  |  |  | Dutta et al., 2020; |
|  | |  |  |  | Efthimiadou et al., 2010; |
|  | |  |  |  | Eichler-Löbermann et al., 2021; |
|  | |  |  |  | Gaind and Singh, 2015a; |
|  | |  |  |  | García-Ruiz et al., 2008; |
|  | |  |  |  | García-Ruiz et al., 2012; |
|  | |  |  |  | Guan et al., 2011; |
|  | |  |  |  | Haynes and Williams, 1999; |
|  | |  |  |  | Jiang et al., 2019; |
|  | |  |  |  | Lalande et al., 2003; |
|  | |  |  |  | Martínez et al., 2018; |
|  | |  |  |  | Moharana et al., 2022; |
|  | |  |  |  | Monokrousos et al., 2006; |
|  | |  |  |  | Moreno et al., 1998; |
|  | |  |  |  | Pajares et al., 2009; |
|  | |  |  |  | Pramanik et al., 2017; |
|  | |  |  |  | Prasanthi et al., 2019; |
|  | |  |  |  | Radhakrishnan et al., 2022; |
|  | |  |  |  | Rao et al., 1997; |
|  | |  |  |  | Ros et al., 2007; |
|  | |  |  |  | Sarkar et al., 2020; |
|  | |  |  |  | Sharma et al., 2013b; |
|  | |  |  |  | Simanca Fontalvo and Cuervo Andrade, 2018; |
|  | |  |  |  | Singh et al., 2015; |
|  | |  |  |  | Singh et al., 2020; |
|  | |  |  |  | Sudhakaran et al., 2019; |
|  | |  |  |  | ﻿Tejada et al., 2006; |
|  | |  |  |  | Tuti et al., 2020; |
|  | | ALP1 | Positive | 43 | Adeleke et al., 2021; |
|  | |  |  |  | Aher et al., 2019; |
|  | |  |  |  | Akmal et al., 2019b; |
|  | |  |  |  | Atoloye et al., 2021; |
|  | |  |  |  | Basak et al., 2017; |
|  | |  |  |  | Blaise and Rao, 2004; |
|  | |  |  |  | Bobul'ská et al., 2015; |
|  | |  |  |  | Brennan and Acosta-Martinez, 2019; |
|  | |  |  |  | Caballero Vanegas et al., 2018; |
|  | |  |  |  | Chang et al., 2007; |
|  | |  |  |  | Chatterjee et al., 2021; |
|  | |  |  |  | Dhull et al., 2004; |
|  | |  |  |  | Durrer et al., 2021; |
|  | |  |  |  | Dutta et al., 2020; |
|  | |  |  |  | Efthimiadou et al., 2010; |
|  | |  |  |  | Eichler-Löbermann et al., 2021; |
|  | |  |  |  | Fereidooni et al., 2013; |
|  | |  |  |  | Gaind and Singh, 2016; |
|  | |  |  |  | García-Ruiz et al., 2008; |
|  | |  |  |  | Gigliotti et al., 2001; |
|  | |  |  |  | Krey et al., 2011; |
|  | |  |  |  | Kumar et al., 2021a; |
|  | |  |  |  | Meena et al., 2016; |
|  | |  |  |  | ﻿Melero et al., 2006; |
|  | |  |  |  | Melero et al., 2007a; |
|  | |  |  |  | Melero Sanchez et al., 2008; |
|  | |  |  |  | Melero et al., 2008a; |
|  | |  |  |  | Melero et al., 2008b; |
|  | |  |  |  | Moharana et al., 2022; |
|  | |  |  |  | Monokrousos et al., 2006; |
|  | |  |  |  | ﻿Okur et al., 2006; |
|  | |  |  |  | Pandey and Pandey, 2009 |
|  | |  |  |  | Prasanthi et al., 2019; |
|  | |  |  |  | Ram et al., 2019; |
|  | |  |  |  | Ramanandan et al., 2020; |
|  | |  |  |  | Rao et al., 1997; |
|  | |  |  |  | Sharma et al., 2013b; |
|  | |  |  |  | Singh et al., 2020; |
|  | |  |  |  | Sudhakaran et al., 2019; |
|  | |  |  |  | Tavali et al., 2021; |
|  | |  |  |  | Tejada and Gonzalez, 2007; |
|  | |  |  |  | Tejada and González, 2009; |
|  | |  |  |  | Truu et al., 2008; |
|  | | ACP, ALP2 | Positive | 1 | Miao et al., 2019; |
| Manure | | ACP1 | Positive | 22 | Acosta-Martinez et al., 2011b; |
|  | |  |  |  | Ali et al., 2019; |
|  | |  |  |  | Antonious C.F., 2009; |
|  | |  |  |  | Balota et al., 2014; |
|  | |  |  |  | Bhambure et al., 2018; |
|  | |  |  |  | Chakrabarti et al., 2000; |
|  | |  |  |  | Diallo-Diagne et al., 2016; |
|  | |  |  |  | Dick et al., 1988; |
|  | |  |  |  | Dinesh et al., 2012; |
|  | |  |  |  | Dora et al., 2006; |
|  | |  |  |  | Gopinath et al., 2009; |
|  | |  |  |  | Hazarika et al., 2021; |
|  | |  |  |  | Kobierski et al., 2017; |
|  | |  |  |  | Kuziemska et al., 2020; |
|  | |  |  |  | Li et al., 2012; |
|  | |  |  |  | Mahajan et al., 2021; |
|  | |  |  |  | Mani et al., 2020; |
|  | |  |  |  | Martyniuk et al., 2019; |
|  | |  |  |  | Romanya et al., 2017; |
|  | |  |  |  | Saha et al., 2008a; |
|  | |  |  |  | Tiecher et al., 2017; |
|  | |  |  |  | Xu et al., 2019; |
|  | | ALP1 | Positive | 29 | Antonious C.F., 2009; |
|  | |  |  |  | Böhme et al., 2005; |
|  | |  |  |  | Chaudhary et al., 2015; |
|  | |  |  |  | Delgado et al., 2012; |
|  | |  |  |  | Dick et al., 1988; |
|  | |  |  |  | Dora et al., 2006; |
|  | |  |  |  | Fereidooni et al., 2013; |
|  | |  |  |  | Fraser et al., 2015; |
|  | |  |  |  | Gaind and Nain, 2010; |
|  | |  |  |  | Garg and Bahl, 2008; |
|  | |  |  |  | Gopinath et al., 2009; |
|  | |  |  |  | Hojati and Nourbakhsh, 2006; |
|  | |  |  |  | Kobierski et al., 2017; |
|  | |  |  |  | Kumar et al., 2021b; |
|  | |  |  |  | Langer and Klimanek, 2006; |
|  | |  |  |  | Li et al., 2012; |
|  | |  |  |  | Liu and Zhou, 2017; |
|  | |  |  |  | Liu et al., 2010; |
|  | |  |  |  | Mani et al., 2020; |
|  | |  |  |  | Manna et al., 2007; |
|  | |  |  |  | Pandey et al., 2008; |
|  | |  |  |  | Qin et al., 2020; |
|  | |  |  |  | Ramesh et al., 2009; |
|  | |  |  |  | Saha et al., 2008a; |
|  | |  |  |  | Saha et al., 2008b; |
|  | |  |  |  | Shi et al., 2019b; |
|  | |  |  |  | Wang et al., 2012; |
|  | |  |  |  | Yang et al., 2018; |
|  | |  |  |  | Zhao et al., 2009; |
| Manure + mineral fertilizer | | ACP1 | Positive | 26 | Alguacil et al., 2003; |
|  | |  |  |  | Ali et al., 2019; |
|  | |  |  |  | Bera et al., 2016; |
|  | |  |  |  | Bhatt et al., 2016; |
|  | |  |  |  | Billah et al., 2020; |
|  | |  |  |  | Biswas et al., 2018; |
|  | |  |  |  | Cao et al., 2022; |
|  | |  |  |  | Choudhary et al., 2021; |
|  | |  |  |  | Damian et al., 2021; |
|  | |  |  |  | Dinesh et al., 2012; |
|  | |  |  |  | Elbl et al., 2019; |
|  | |  |  |  | Gagnon et al., 1999; |
|  | |  |  |  | Hatti et al., 2018; |
|  | |  |  |  | Jiang et al., 2019; |
|  | |  |  |  | Laxminarayana K., 2017; |
|  | |  |  |  | Masto et al., 2006; |
|  | |  |  |  | Meshram et al., 2016; |
|  | |  |  |  | Moro et al., 2021; |
|  | |  |  |  | Omenda et al., 2019; |
|  | |  |  |  | Qaswar et al., 2020; |
|  | |  |  |  | Roohi et al., 2020; |
|  | |  |  |  | Saha et al., 2019; |
|  | |  |  |  | Shao et al., 2014; |
|  | |  |  |  | Singh et al., 2015; |
|  | |  |  |  | Singh et al., 2018b; |
|  | |  |  |  | Wei et al., 2017; |
|  | | ALP1 | Positive | 26 | Akmal et al., 2019a; |
|  | |  |  |  | Bera et al., 2016; |
|  | |  |  |  | Bhatt et al., 2016; |
|  | |  |  |  | Biswas et al., 2018; |
|  | |  |  |  | Cao et al., 2022; |
|  | |  |  |  | Choudhary et al., 2021; |
|  | |  |  |  | Colvan et al., 2001; |
|  | |  |  |  | Gagnon et al., 1999; |
|  | |  |  |  | Goyal et al., 1999; |
|  | |  |  |  | Guo et al., 2021; |
|  | |  |  |  | Jia et al., 2018; |
|  | |  |  |  | Kaur et al., 2017; |
|  | |  |  |  | Laxminarayana K., 2017; |
|  | |  |  |  | Mandal et al., 2007; |
|  | |  |  |  | Manna et al., 2007; |
|  | |  |  |  | Masto et al., 2006; |
|  | |  |  |  | Meshram et al., 2016; |
|  | |  |  |  | Roohi et al., 2020; |
|  | |  |  |  | Saha et al., 2019; |
|  | |  |  |  | Sharma et al., 2015; |
|  | |  |  |  | Singh et al., 2020; |
|  | |  |  |  | Singh et al., 2018b; |
|  | |  |  |  | Wei et al., 2017; |
|  | |  |  |  | Wyszkowska and Wyszkowski, 2010; |
|  | |  |  |  | Xu et al., 2018; |
|  | |  |  |  | Zhao et al., 2009; |
|  | | ACP, ALP2 | Positive | 1 | Miao et al., 2019; |
| Organic phosphorus | ACP1 | Positive | 1 | Guan et al., 2013; |
|  | ALP1 | Positive | 3 | Durrer et al., 2021; |
|  |  |  |  | Shi et al., 2021; |
|  |  |  |  | Verma et al., 2021; |
| Vermicompost | | ACP1 | Positive | 7 | Aechra et al., 2021; |
|  | |  |  |  | Das et al., 2021; |
|  | |  |  |  | Hazarika et al., 2021; |
|  | |  |  |  | Ruiz and Salas, 2019; |
|  | |  |  |  | Saha et al., 2008a; |
|  | |  |  |  | Tejada and Benítez, 2011; |
|  | |  |  |  | Zhang et al., 2020; |
|  | | ALP1 | Positive | 6 | Becagli et al., 2022; |
|  | |  |  |  | Das et al., 2021; |
|  | |  |  |  | Dubey et al., 2020; |
|  | |  |  |  | Nisha et al., 2019; |
|  | |  |  |  | Tejada and González, 2009; |
|  | |  |  |  | Zhang et al., 2020; |
| Biostimulant/biofertilizer  (±microorganisms) | | ACP1 | Positive | 11 | Aechra et al., 2021; |
|  |  |  | Bana et al., 2022a; |
|  | |  |  |  | Bana et al., 2022b; |
|  | |  |  |  | Dubey et al., 2021; |
|  | |  |  |  | Firmano et al., 2021; |
|  | |  |  |  | Fitriatin et al., 2021; |
|  | |  |  |  | García-Martínez et al., 2010; |
|  | |  |  |  | Khandare et al., 2020; |
|  | |  |  |  | Kowalska et al., 2017; |
|  | |  |  |  | Sadeghi and Taban, 2021; |
|  | |  |  |  | Sharma et al., 2013a; |
|  | | ALP1 | Positive | 11 | Bana et al., 2022a; |
|  | |  |  |  | Bana et al., 2022b; |
|  | |  |  |  | Chaudhary et al., 2021; |
|  | |  |  |  | Chaudhary et al., 2022; |
|  | |  |  |  | Dubey et al., 2021; |
|  | |  |  |  | Firmano et al., 2021; |
|  | |  |  |  | Guo et al., 2021; |
|  | |  |  |  | Kaur et al., 2017; |
|  | |  |  |  | Khandare et al., 2020; |
|  | |  |  |  | Kowalska et al., 2017; |
|  | |  |  |  | Niewiadomska et al., 2020a; |
| Biowaste fertilizer | | ACP1 | Positive | 5 | El-Bassi et al., 2021; |
|  | |  |  |  | Krey et al., 2011; |
|  | |  |  |  | Rajashekhara and Siddaramappa, 2008; |
|  | |  |  |  | Romero et al., 2005; |
|  | |  |  |  | Tejada et al., 2006; |
|  | | ALP1 | Positive | 6 | Emmerling et al., 2010; |
|  | |  |  |  | Hashimoto et al., 2009 |
|  | |  |  |  | Mbarki et al., 2010; |
|  | |  |  |  | Meli et al., 2007; |
|  | |  |  |  | Piotrowska et al., 2006; |
|  | |  |  |  | Tejada et al., 2007; |
| Sludge | | ACP1 | Positive | 6 | Bhattacharyya et al., 2001; |
|  | |  |  |  | Gagnon et al., 1999; |
|  | |  |  |  | Gagnon et al., 2003; |
|  | |  |  |  | Moreira et al., 2017; |
|  | |  |  |  | Pascual et al., 2007 |
|  | |  |  |  | Siebielec et al., 2018; |
|  | |  | None | 1 | Alvarenga et al., 2008 |
|  | | ALP1 | Positive | 15 | Carbonell et al., 2009; |
|  | |  |  |  | Dhanker et al., 2020; |
|  | |  |  |  | Dhanker et al., 2021; |
|  | |  |  |  | Frąc M., 2011; |
|  | |  |  |  | Ghosh et al., 2019; |
|  | |  |  |  | Lakhdar et al., 2011; |
|  | |  |  |  | Liu et al., 2020; |
|  | |  |  |  | Meena et al., 2016; |
|  | |  |  |  | Meena et al., 2018; |
|  | |  |  |  | ﻿N'Dayegamiye et al., 2006; |
|  | |  |  |  | Pascual et al., 2007; |
|  | |  |  |  | Roy et al., 2019; |
|  | |  |  |  | Siebielec et al., 2018; |
|  | |  |  |  | Tavali et al., 2021; |
|  | |  |  |  | Xie et al., 2011; |
| Green manure | ACP1 | Positive | 2 | Pérez Brandan et al., 2017; |
|  |  |  |  | Zhaolei et al., 2017; |
|  | ALP1 | Positive | 1 | Janaki et al., 2021; |
| Green manure + fertilizer | ACP1 | Positive | 1 | Bolton et al., 1985; |
|  |  | None | 3 | Elfstrand et al., 2007a; |
|  |  |  |  | Elfstrand et al., 2007b; |
|  |  |  |  | Onkum and Teamkao, 2020; |
|  | ALP1 | Positive | 1 | Dhull et al., 2004; |
| Crop residue management | ACP1 | Positive | 8 | Chatterjee et al., 2021; |
|  |  |  |  | Nath et al., 2017; |
|  |  |  |  | Nath et al., 2021; |
|  |  |  |  | Qaswar et al., 2020; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Sharma et al., 2019a; |
|  |  |  |  | Singh et al., 2018; |
|  |  |  |  | Yang et al., 2019; |
|  |  | Negative | 1 | Peruccci et al., 1985; |
|  | ALP1 | Positive | 22 | Chatterjee et al., 2021; |
|  |  |  |  | Choudhary et al., 2018a; |
|  |  |  |  | Gaind and Nain, 2007; |
|  |  |  |  | Galvez et al., 2012; |
|  |  |  |  | Hai-Ming et al., 2014; |
|  |  |  |  | Hazra et al., 2021; |
|  |  |  |  | Jat et al., 2020; |
|  |  |  |  | Khan et al., 2022; |
|  |  |  |  | ﻿Melero et al., 2006; |
|  |  |  |  | Melero et al., 2009; |
|  |  |  |  | Moreno-Cornejo et al., 2017; |
|  |  |  |  | Nath et al., 2021; |
|  |  |  |  | Peruccci et al., 1985; |
|  |  |  |  | Pooniya et al., 2022; |
|  |  |  |  | Sepat et al., 2014; |
|  |  |  |  | Sharma et al., 2019a; |
|  |  |  |  | Singh et al., 2018; |
|  |  |  |  | Tao et al., 2009; |
|  |  |  |  | Tejada et al., 2009; |
|  |  |  |  | Ullah et al., 2020; |
|  |  |  |  | Wei et al., 2014a; |
|  |  |  |  | Yang et al., 2019; |
| Straw residues | ACP1 | Positive | 3 | Arun et al., 2020; |
|  |  |  |  | Cao et al., 2022; |
|  |  |  |  | Wei et al., 2021; |
|  | ALP1 | Positive | 7 | Arun et al., 2020; |
|  |  |  |  | Cao et al., 2022; |
|  |  |  |  | Cui et al., 2022; |
|  |  |  |  | Singh and Sharma, 2020; |
|  |  |  |  | Singh et al., 2022; |
|  |  |  |  | Ullah et al., 2018a; |
|  |  |  |  | Zhang et al., 2016a; |
| Mulching | ACP1 | Positive | 5 | Arun et al., 2020; |
|  |  |  |  | ﻿Balota et al., 2004; |
|  |  |  |  | Benítez et al., 2000; |
|  |  |  |  | da Silva Xavier et al., 2020; |
|  |  |  |  | Zhu et al., 2022; |
|  |  | None | 1 | Jain et al., 2018; |
|  | ALP1 | Positive | 5 | Arun et al., 2020; |
|  |  |  |  | ﻿Balota et al., 2004; |
|  |  |  |  | Buck et al., 2000; |
|  |  |  |  | Rao et al., 1997; |
|  |  |  |  | Wang et al., 2014a; |
|  |  | None | 1 | Jain et al., 2018; |
| Biochar | ACP1 | Positive | 7 | Akmal et al., 2019a; |
|  |  |  |  | Akmal et al., 2019b; |
|  |  |  |  | Egamberdieva et al., 2019; |
|  |  |  |  | El-Bassi et al., 2021; |
|  |  |  |  | Noronha et al., 2022; |
|  |  |  |  | Salam et al., 2019; |
|  |  |  |  | Wojewódzki et al., 2022; |
|  |  | Negative | 1 | Yuan et al., 2022; |
|  | ALP1 | Positive | 14 | Ali et al., 2017; |
|  |  |  |  | Azeem et al., 2021; |
|  |  |  |  | Becagli et al., 2022; |
|  |  |  |  | Becagli et al., 2022; |
|  |  |  |  | Du et al., 2014; |
|  |  |  |  | Dubey et al., 2020; |
|  |  |  |  | Guo et al., 2021; |
|  |  |  |  | Jabborova et al., 2021; |
|  |  |  |  | Khan et al., 2022; |
|  |  |  |  | Masto et al., 2013; |
|  |  |  |  | Saha et al., 2019; |
|  |  |  |  | Wojewódzki et al., 2022; |
|  |  |  |  | Yao et al., 2021; |
|  |  |  |  | Zhu et al., 2017; |
|  | ALP2 | Positive | 1 | Pokharel et al., 2020; |
| Burning | ACP1 | Negative | 3 | Dick et al., 1988; |
|  |  |  |  | Hoyle and Murphy, 2006; |
|  |  |  |  | Trujillo-Narcía et al., 2019; |
|  | ALP1 | Negative | 3 | Ajwaa et al., 1999; |
|  |  |  |  | Peruccci et al., 1984; |
|  |  |  |  | Perucci et al., 2007; |
| Phosphate solubilizing bacteria | ACP1 | Positive | 7 | Aechra et al., 2021; |
|  |  |  |  | Chatterjee et al., 2021; |
|  |  |  |  | Khandare et al., 2020; |
|  |  |  |  | Khuong et al., 2018; |
|  |  |  |  | Krey et al., 2011; |
|  |  |  |  | Liu et al., 2021b; |
|  |  |  |  | Pareek et al., 2019; |
|  | ALP1 | Positive | 9 | Basak et al., 2017; |
|  |  |  |  | Biswas et al., 2021; |
|  |  |  |  | Chatterjee et al., 2021; |
|  |  |  |  | Chaudhary et al., 2022; |
|  |  |  |  | Gaind and Nain, 2007; |
|  |  |  |  | Khandare et al., 2020; |
|  |  |  |  | Krey et al., 2011; |
|  |  |  |  | Naragund et al., 2020; |
|  |  |  |  | Pareek et al., 2019; |
| Plant beneficial bacteria | ACP1 | Positive | 11 | Benbrik et al., 2021; |
|  |  |  |  | Bhambure et al., 2018; |
|  |  |  |  | Billah et al., 2020; |
|  |  |  |  | de Cássia et al., 2018; |
|  |  |  |  | Gospodarek et al., 2021; |
|  |  |  |  | Idris and Yuliar, 2021; |
|  |  |  |  | Rajeela et al., 2017; |
|  |  |  |  | Madhaiyan et al., 2009 |
|  |  |  |  | Mercl et al., 2020; |
|  |  |  |  | Rouydel et al., 2021; |
|  |  |  |  | Verma et al., 2016b; |
|  |  | Negative | 2 | de Barros et al., 2019; |
|  |  |  |  | Makoi et al., 2010 |
|  |  | None | 1 | Ruiz and Salas, 2019; |
|  | ALP1 | Positive | 16 | Ali et al., 2017; |
|  |  |  |  | Benbrik et al., 2021; |
|  |  |  |  | Chaudhary et al., 2021; |
|  |  |  |  | Cui et al., 2015; |
|  |  |  |  | de Cássia et al., 2018; |
|  |  |  |  | Dubey et al., 2021; |
|  |  |  |  | Emami et al., 2022; |
|  |  |  |  | Idris and Yuliar, 2021; |
|  |  |  |  | Kohler et al., 2007; |
|  |  |  |  | Manjunath et al., 2016; |
|  |  |  |  | Nakas et al., 1987; |
|  |  |  |  | Omara et al., 2017; |
|  |  |  |  | Rouydel et al., 2021; |
|  |  |  |  | Schoebitz et al., 2019; |
|  |  |  |  | Valarini et al., 2003; |
|  |  |  |  | Verma et al., 2016b; |
|  |  | Negative | 2 | Makoi et al., 2010; |
|  |  |  |  | Mercl et al., 2020; |
| Arbuscular mycorrhizal fungi | ACP1 | Positive | 17 | de Barros et al., 2019; |
|  |  |  |  | Ferreira-Vilela et al., 2014; |
|  |  |  |  | Hu et al., 2019b; |
|  |  |  |  | Hu et al., 2019a; |
|  |  |  |  | Kim et al., 2002; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Manjunath et al., 2016; |
|  |  |  |  | Nakas et al., 1987; |
|  |  |  |  | Sales et al., 2021; |
|  |  |  |  | Sharma et al., 2013a; |
|  |  |  |  | Tarafdar and Rao, 1996; |
|  |  |  |  | Tarafdar and Gharu, 2006; |
|  |  |  |  | Turan V., 2021; |
|  |  |  |  | Wang et al., 2013c; |
|  |  |  |  | Yadav et al., 2007; |
|  |  |  |  | Yin et al., 2021; |
|  |  |  |  | Zhang et al., 2019b; |
|  |  | None | 2 | Wakelin et al., 2007; |
|  |  |  |  | Izaguirre-Mayoral et al., 2000; |
|  | ALP1 | Positive | 8 | Chatterjee et al., 2021; |
|  |  |  |  | de Barros et al., 2019; |
|  |  |  |  | Gaind and Nain, 2007; |
|  |  |  |  | Kohler et al., 2008; |
|  |  |  |  | Laxminarayana K., 2017; |
|  |  |  |  | Tarafdar and Rao, 1996; |
|  |  |  |  | Tarafdar and Gharu, 2006; |
|  |  |  |  | Yadav et al., 2007; |
|  | ALP1 | None | 1 | Wakelin et al., 2007; |

*Table S13. Single studies and reviews of APase response relationships to weed and pest management practices.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Management practice** | **APase**  **(single study1 or review2)** | **Response relationship** | **Vote counting** | **Study** |
| Manual weeding vs chemical | ACP1 | Positive | 3 | Bhatt et al., 2016; |
|  |  |  |  | Majumdar et al., 2010; |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  | ALP1 | Positive | 5 | Bhatt et al., 2016; |
|  |  |  |  | Majumdar et al., 2010 |
|  |  |  |  | Nedunchezhiyan et al., 2018; |
|  |  |  |  | Ullah et al., 2018b; |
|  |  |  |  | Ullah et al., 2020; |
| Herbicides | ACP1 | Negative | 4 | Carter et al., 2007; |
|  |  |  |  | Cycoń et al., 2013; |
|  |  |  |  | Savin et al., 2009; |
|  |  |  |  | Wyszkowska J., 2002; |
|  |  | None | 6 | Arya et al., 2018; |
|  |  |  |  | Majumdar et al., 2010 |
|  |  |  |  | Meher et al., 2021; |
|  |  |  |  | Pozo et al., 1994; |
|  |  |  |  | Sofo et al., 2012; |
|  |  |  |  | Tomkiel et al., 2018; |
|  | ALP1 | Negative | 7 | Cycoń et al., 2013; |
|  |  |  |  | Rasool et al., 2014; |
|  |  |  |  | Saha et al., 2016; |
|  |  |  |  | Savin et al., 2009; |
|  |  |  |  | Singh and Gohshal, 2013; |
|  |  |  |  | Sofo et al., 2012; |
|  |  |  |  | Wyszkowska J., 2002; |
|  |  | None | 6 | Majumdar et al., 2010; |
|  |  |  |  | Meher et al., 2021; |
|  |  |  |  | Nivelle et al., 2018; |
|  |  |  |  | Pozo et al., 1994; |
|  |  |  |  | Tejada et al., 2017; |
|  |  |  |  | Tomkiel et al., 2018; |
|  | ACP, ALP2 | None | 1 | Riah et al., 2014; |
| Fungicides | ACP1 | Negative | 2 | Chen et al., 2001; |
|  |  |  |  | Wang et al., 2022c; |
|  |  | None | 3 | Ntalli et al., 2019b; |
|  |  |  |  | Pozo et al., 1995; |
|  |  |  |  | Singh N., 2005; |
|  | ACP2 | Positive |  | Riah et al., 2014; |
|  | ALP1 | Negative | 1 | Ntalli et al., 2019a; |
|  |  | None | 3 | Baćmaga et al., 2019; |
|  |  |  |  | Pozo et al., 1995; |
|  |  |  |  | Wang et al., 2022c; |
|  | ALP2 | Negative |  | Riah et al., 2014; |
| Insecticides | ACP1 | Negative | 4 | Dinesh et al., 1995; |
|  |  |  |  | García-Martínez et al., 2010; |
|  |  |  |  | Megharaj et al., 1999; |
|  |  |  |  | Tu C.M., 1995; |
|  |  | None | 3 | Megharaj et al., 1999; |
|  |  |  |  | Racke et al., 1996; |
|  |  |  |  | Tu C.M., 1995; |
|  | ACP2 | Negative | 1 | Riah et al., 2014; |
|  | ALP1 | Recovery with time | 3 | Cycoń Piotrowska-Seget, 2015; |
|  |  |  |  | Mahapatra et al., 2017; |
|  |  |  |  | Pandey et al., 2006; |
|  |  | None | 1 | Racke et al., 1996; |
|  | ALP2 | Recovery with time | 1 | Riah et al., 2014; |

*S14. Single and meta-analysis studies of APase response relationships to irrigation practice.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Irrigation practice** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Optimal irrigation | ACP1 | Positive | 10 | D’Ascoli et al., 2006; |
|  |  |  |  | George et al., 2013; |
|  |  |  |  | He et al., 2010; |
|  |  |  |  | Li et al., 2017a; |
|  |  |  |  | Pascual et al., 2007; |
|  |  |  |  | Sharma et al., 2013b; |
|  |  |  |  | Wang et al., 2013c; |
|  |  |  |  | Zhang et al., 2019a; |
|  |  |  |  | Zhang et al., 2021; |
|  |  |  |  | Zhong et al., 2007; |
|  | ACP2 | Positive | 1 | Sun et al., 2020; |
|  | ALP1 | Positive | 10 | Abdalla and Lager, 2009; |
|  |  |  |  | George et al., 2013; |
|  |  |  |  | He et al., 2010; |
|  |  |  |  | Jia et al., 2018; |
|  |  |  |  | Kumar et al., 2021b; |
|  |  |  |  | Li et al., 2018c; |
|  |  |  |  | Pascual et al., 2007; |
|  |  |  |  | Romero-Trigueros et al., 2021; |
|  |  |  |  | Sharma et al., 2013b; |
|  |  |  |  | Tan et al., 2009; |
| Waste water irrigation | ACP1 | Positive | 1 | Meli et al., 2002; |
|  |  | Negative | 1 | Masto et al., 2008 |
|  |  | None | 1 | Santos et al., 2016; |
|  | ALP1 | Positive | 4 | Bhattachayya et al., 2008; |
|  |  |  |  | García-Orenes et al., 2015; |
|  |  |  |  | Lal et al., 2015; |
|  |  |  |  | Meli et al., 2002; |
|  |  | Negative | 1 | Masto et al., 2008 |
|  |  | None | 3 | Adrover et al., 2007; |
|  |  |  |  | Adrover et al., 2017; |
|  |  |  |  | Kayikcioglu H.H., 2018; |

*Table S15. Single studies of APase response relationships to livestock,grazing and mowing management.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Management type** | **APase** | **Response relationship** | **Vote counting** | **Study** |
| Crop-livestock | ACP | Positive | 5 | de Jesus Franco et al., 2020; |
|  |  |  |  | Izquierdo et al., 2003; |
|  |  |  |  | Damian et al., 2021; |
|  |  |  |  | Martins Sousa et al., 2020; |
|  |  |  |  | Silva et al., 2015; |
| Grazing | ACP | Positive | 4 | Bardgett and Leemans, 1995; |
|  |  |  |  | George et al., 2013; |
|  |  |  |  | Ramos et al., 2011; |
|  |  |  |  | Ramos et al., 2010; |
|  | ALP | Positive | 2 | Galindo et al., 2020; |
|  |  |  |  | George et al., 2013; |
| Mowing | ALP | Negative | 1 | Zibilske and Makus, 2009; |

*Table S16. Single and meta-analysis studies of APase response relationships to soil pollutant content.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pollutant** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Heavy metals |  |  |  |  |
| Lead | ACP1 | Negative | 5 | Bartkowiak et al., 2021; |
|  |  |  |  | Chowdhury and Rasid, 2021b; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Li et al., 2009; |
|  |  |  |  | Papa et al., 2009 |
|  | ALP1 | Negative | 5 | Bartkowiak et al., 2021; |
|  |  |  |  | Bhattachayya et al., 2008 |
|  |  |  |  | Calvarro et al., 2014; |
|  |  |  |  | de Santiago-Martín et al., 2013; |
|  |  |  |  | Lemanowicz et al., 2016; |
| Chromium | ACP1 | Negative | 3 | Bartkowiak et al., 2021; |
|  |  |  |  | Chowdhury and Rasid, 2021a; |
|  |  |  |  | Wyszkowska et al., 2001; |
|  | ALP1 | Negative | 2 | Bartkowiak et al., 2021; |
|  |  |  |  | Wyszkowska et al., 2001; |
| Nickel | ACP1 | Negative | 2 | Antonious C.F., 2009; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  | ALP1 | Negative | 4 | Antonious C.F., 2009; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Pandey and Pandey, 2009; |
|  |  |  |  | Wyszkowska et al., 2005; |
| Zinc | ACP1 | Positive | 1 | Mandal et al., 2021; |
|  |  | Negative | 4 | Chowdhury and Rasid, 2021a; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Li et al., 2018d; |
|  |  |  |  | Ros et al., 2008 |
|  | ALP1 | Positive | 1 | Mandal et al., 2021; |
|  |  | Negative | 7 | Calvarro et al., 2014; |
|  |  |  |  | de Santiago-Martín et al., 2013; |
|  |  |  |  | Fernández et al., 2014; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Liu et al., 2020; |
|  |  |  |  | Łukowski and Dec, 2018; |
|  |  |  |  | Pandey and Pandey, 2009; |
| Cadmium | ACP1 | Negative | 2 | Chowdhury and Rasid, 2021b; |
|  |  |  |  | Li et al., 2009; |
|  | ACP2 | Positive | 1 | Aponte et al., 2020; |
|  | ALP1 | Positive | 1 | Ogunkunle et al., 2020; |
|  |  | Negative | 4 | Calvarro et al., 2014; |
|  |  |  |  | Dar G., 1996; |
|  |  |  |  | de Santiago-Martín et al., 2013; |
|  |  |  |  | Pandey and Pandey, 2009; |
| Copper | ACP1 | Positive | 1 | Belyaeva et al., 2005; |
|  |  | Negative | 8 | Bartkowiak et al., 2021; |
|  |  |  |  | Dewey et al., 2012; |
|  |  |  |  | Fernández-Calviño et al., 2010 |
|  |  |  |  | Lebrun et al., 2012; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Li et al., 2009; |
|  |  |  |  | Papa et al., 2009 |
|  |  |  |  | Ros et al., 2008 |
|  | ACP2 | Positive | 1 | Aponte et al., 2020; |
|  | ALP1 | Negative | 7 | Bartkowiak et al., 2021; |
|  |  |  |  | Bhattachayya et al., 2008 |
|  |  |  |  | Calvarro et al., 2014; |
|  |  |  |  | de Santiago-Martín et al., 2013; |
|  |  |  |  | Kuziemska et al., 2020; |
|  |  |  |  | Lemanowicz et al., 2016; |
|  |  |  |  | Pandey and Pandey, 2009; |
| Manganese | ACP1 | Negative | 2 | Li et al., 2009; |
|  |  |  |  | Ros et al., 2008 |
| Arsenic | ACP1 | Negative | 1 | Garg and Cheema, 2021; |
|  | ALP | Negative | 1 | Garg and Cheema, 2021; |
| Mercury | ACP2 | Negative | 1 | Aponte et al., 2020; |
|  | ALP1 | Negative | 1 | Casucci et al., 2003; |
|  | ALP2 | Negative | 1 | Aponte et al., 2020; |
| Sewage sludge compost | ACP1 | Negative | 3 | Antolín et al., 2005; |
|  |  |  |  | Kunito et al., 2001; |
|  |  |  |  | Moreno et al., 1998; |
|  | ALP1 | Negative | 5 | Dar G., 1996; |
|  |  |  |  | Fernández et al., 2014; |
|  |  |  |  | Kunito et al., 2001; |
|  |  |  |  | Stoven and Schnug, 2009; |
|  |  |  |  | Wang et al., 2021b; |
| Petroleum  diesel | ACP1 | Negative | 2 | Wyszkowska et al., 2002; |
|  |  |  |  | Wyszkowska and Wyszkowski, 2010; |
|  | ALP1 | Negative | 4 | Gospodarek et al., 2021; |
|  |  |  |  | Serrano et al., 2009; |
|  |  |  |  | Wyszkowska et al., 2002; |
|  |  |  |  | Wyszkowska and Wyszkowski, 2010; |
| Nanomaterials |  |  |  |  |
| Carbon, copper, silver | ACP2 | Negative | 1 | Lin et al., 2021; |
| Iron | ACP2 | Positive | 1 | Lin et al., 2021; |

*Table S17. Single and meta-analysis studies of APase responses to the increase of different climate change variables.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **APase**  **(single1 or meta-analysis2 study)** | **Response relationship** | **Vote counting** | **Study** |
| Mean annual temperature | ACP1 | Positive | 1 | Ghiloufi and Chaieb, 2021; |
|  |  | Negative | 1 | Chen et al., 2021b; |
|  | ACP2 | Positive | 2 | Sun et al., 2020; |
|  |  |  |  | Meng et al., 2020; |
|  | ALP1 | Negative | 1 | Wang et al., 2021a; |
|  | ACP, ALP2 | None | 1 | Margalef et al., 2021; |
| Mean annual precipitation | ACP1 | Positive | 1 | Ghiloufi and Chaieb, 2021; |
|  | ACP2 | Positive | 1 | Sun et al., 2020; |
|  | ALP1 | Positive | 2 | Habig and Swanepoel, 2015; |
|  |  |  |  | Morugán-Coronado et al., 2019; |
| Drought | ACP1 | Positive | 1 | Caballero Vanegas et al., 2018; |
|  |  | Negative | 2 | Gunes et al., 2007 |
|  |  |  |  | Egamberdieva et al., 2019; |
|  | ALP1 | Positive | 1 | Caballero Vanegas et al., 2018; |
|  |  | Negative | 1 | Egamberdieva et al., 2019; |
|  | ACP, ALP2 | Negative | 2 | Gou et al., 2020; |
|  |  |  |  | Margalef et al., 2021; |
| Soil water scarcity | ACP1 | Negative | 1 | Ghiloufi and Chaieb, 2021; |
|  |  | None | 2 | Mazzuchelli et al., 2020; |
|  |  |  |  | Zago et al., 2018; |
|  | ACP, ALP2 | Negative | 1 | Gou et al., 2020; |
| Soil water availability | ACP1 | Positive | 2 | Figueira da Silva et al., 2020; |
|  |  |  |  | Izquierdo et al., 2003; |
|  | ALP1 | Positive | 2 | Fraser et al., 2015; |
|  |  |  |  | Jabborova et al., 2021; |
| Seasonal variations |  |  |  |  |
| Rainy season | ACP1 | Positive | 14 | Arora et al., 2021; |
|  |  |  |  | Bachmann et al., 2014; |
|  |  |  |  | Bolton et al., 1985; |
|  |  |  |  | Carlos et al., 2022; |
|  |  |  |  | Dormaar and Willms, 2000; |
|  |  |  |  | Elfstrand et al., 2007b; |
|  |  |  |  | García-Ruiz et al., 2009; |
|  |  |  |  | Jaskulska et al., 2020b; |
|  |  |  |  | Koper and Lemanowicz, 2008; |
|  |  |  |  | Li et al., 2021a; |
|  |  |  |  | Mejia Guerra et al., 2018; |
|  |  |  |  | Mina et al., 2008 |
|  |  |  |  | Silvestro et al., 2017; |
|  |  |  |  | Singh et al., 2012a; |
|  | ALP1 | Positive | 11 | Angers et al., 1993; |
|  |  |  |  | Arora et al., 2021; |
|  |  |  |  | Bachmann et al., 2014; |
|  |  |  |  | Du et al., 2014; |
|  |  |  |  | Efthimiadou et al., 2010; |
|  |  |  |  | Koper and Lemanowicz, 2008; |
|  |  |  |  | Łukowski and Dec, 2018; |
|  |  |  |  | Meli et al., 2002; |
|  |  |  |  | Neha et al., 2020; |
|  |  |  |  | ﻿Okur et al., 2006; |
|  |  |  |  | Shi et al., 2020; |
| Dry season | ACP1 | Negative | 4 | Bolton et al., 1985; |
|  |  |  |  | Hoyle and Murphy, 2006; |
|  |  |  |  | McCallister et al., 2002; |
|  |  |  |  | Tiecher et al., 2012; |
| CO2 fertilization | ALP1 | Positive | 1 | Dey et al., 2019; |
|  | ACP, ALP2 | Positive | 1 | Margalef et al., 2021; |

*Table S18. Single studies of crop yield responses to APase activity.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Crop** | **APase** | **Response relationship** | **Vote counting** | **Study** |
| Wheat | ACP | Positive | 1 | Moharana et al., 2022; |
|  | ALP | Positive | 4 | Borase et al., 2020; |
|  |  |  |  | Furtak et al., 2017; |
|  |  |  |  | Mandal et al., 2007; |
|  |  |  |  | Moharana et al., 2022; |
| Organic Wheat | ACP | Positive | 1 | Dick et al., 1988; |
|  | ALP | Positive | 2 | Sharma et al., 2015; |
|  |  |  |  | Tejada and Gonzalez, 2007; |
| Maize | ACP | Positive | 1 | Wei et al., 2021; |
|  | ALP | Positive | 2 | Furtak et al., 2017; |
|  |  |  |  | Zhou et al., 2022; |
| Organic winter barley | ACP | Positive | 1 | Antolín et al., 2005; |
| Organic beet | ACP | Positive | 1 | Roy et al., 2019; |
|  | ALP | Positive | 1 | Roy et al., 2019; |
| Rice | ACP | Positive | 1 | Zhang et al., 2019a; |
|  | ALP | Negative | 1 | Basak et al., 2017; |
| Organic lentil | ALP | Positive | 1 | Singh et al., 2018b; |
| Broad bean | ACP | Positive | 1 | Gao et al., 2016; |
| Organic plum | ALP | None | 1 | Chocano et al., 2016; |
| Organic orange | ALP | None | 1 | Madejón et al., 2003; |

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