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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Daftar Pustaka

Abd-Alla, M. H., Al-Amri, S. M., & El-Enany, A. W. E. (2023). Enhancing rhizobium–legume symbiosis and reducing nitrogen fertilizer use are potential options for mitigating climate change. *Agriculture (Switzerland)*, *13*(11). https://doi.org/10.3390/agriculture13112092

Adams, M. A., Buckley, T. N., Salter, W. T., Buchmann, N., Blessing, C. H., Turnbull, T. L., & Adams, M. A. (2018). *Contrasting responses of crop legumes and cereals to nitrogen availability*. 1475–1483. https://doi.org/10.1111/nph.14918

Adie, M. M., & Krisnawati, A. (2016). *Biologi tanaman kedelai*. Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbian.

Adisarwanto. (2005). *Budidaya kedelai dengan pemupukan yang efektif dan pengoptimalan peran bintil Akar.* Penebar Swadaya.

Ahmed, S., Raza, M. A., Yuan, X., Du, Y., Iqbal, N., Chachar, Q., Soomro, A. A., Ibrahim, F., Hussain, S., Wang, X., Liu, W., & Yang, W. (2020). Optimized planting time and co-growth duration reduce the yield difference between intercropped and sole soybean by enhancing soybean resilience toward size-asymmetric competition. *Food and Energy Security*, *9*, e226. https://doi.org/10.1002/fes3.226

Ahmed, S., Raza, M., Zhou, T., Hussain, S., Khalid, M., Feng, L., Wasaya, A., Iqbal, N., Ahmed, A., Liu, W., & Yang, W. (2018). Responses of soybean dry matter production, phosphorus accumulation, and seed yield to sowing time under relay intercropping with maize. *Agronomy*, *8*(12), 282. https://doi.org/https://doi.org/10.3390/agronomy8120282

Akchaya, K., Parasuraman, P., Pandian, K., Vijayakumar, S., Thirukumaran, K., Mustaffa, M. R. A. F., Rajpoot, S. K., & Choudhary, A. K. (2025). Boosting resource use efficiency, soil fertility, food security, ecosystem services, and climate resilience with legume intercropping: a review. *Frontiers in Sustainable Food Systems*, *9*, 1–22. https://doi.org/10.3389/fsufs.2025.1527256

Andrews, D. J., & Kassam, A. H. (1976). The importance of multiple cropping in increasing world food supplies. In R. I. Papendick, P. A. Sanchez, & G. B. Triplett (Eds.), *Multiple cropping* (pp. 1–10). ASA Special Publications. https://doi.org/10.2134/asaspecpub27.c1

Andrianto, T. ., & Indarto, N. (2004). *Budidaya dan analisis usaha tani kedelai, kacang hijau, kacang panjang*. Absolut.

Araújo, W. A. de, Santana, R. S., Mauad, M., & da Silva, R. S. (2021). Dry matter accumulation and nutrient uptake in determinate and indeterminate soybeans. *Journal of Plant Nutrition*, *44*(4), 508–522. https://doi.org/10.1080/01904167.2020.1845371

Ashworth, A. J., West, C. P., Allen, F. L., Keyser, P. D., Weiss, S. A., Tyler, D. D., Taylor, A. M., Warwick, K. L., & Beamer, K. P. (2015). Biologically fixed nitrogen in legume intercropped systems: Comparison of nitrogen-difference and nitrogen-15 enrichment techniques. *Agronomy Journal*, *107*(6), 2419–2430. https://doi.org/10.2134/agronj14.0639

Astutik, D., Yudono, P., & Waluyo, S. (2018). The growth of two cultivars mung bean under different sweet corn shelter density in sandy soil coastal area. *Ilmu Pertanian (Agricultural Science)*, *2*(3), 106. https://doi.org/10.22146/ipas.26703

Badan Pusat Statistik. (2021). *Analisis produktivitas jagung dan kedelai di Indonesia, 2021*.

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

BPS-RI.

Bakal, H., Gulluoglu, L., Onat, B., & Arioglu, H. (2017). The effect of growing seasons on some agronomic and quality characteristics of Soybean varieties in mediterranean region in Turkey. *Turkish Journal of Field Crops*, *22*(2), 187–196. https://doi.org/10.17557/tjfc.356213

Balitkabi. (2021). *Denasa 1 dan Denasa 2 varietas unggul baru kedelai toleran naungan dan berbiji besar*. https://balitkabi.litbang.pertanian.go.id/infotek/denasa-1-dan-denasa-2-varietas-unggul-baru-kedelai-toleran-naungan-dan-berbiji-besar/

Becana, M., & Sprent, J. I. (1987). Nitrogen fixation and nitrate reduction in the root nodules of legumes. *Physiologia Plantarum*, *70*(4), 757–765. https://doi.org/10.1111/j.1399-3054.1987.tb04335.x

Bedoussac, L., Journet, E. P., Hauggaard-Nielsen, H., Naudin, C., Corre-Hellou, G., Jensen, E. S., Prieur, L., & Justes, E. (2015). Ecological principles underlying the increase of productivity achieved by cereal-grain legume intercrops in organic farming. A review. *Agronomy for Sustainable Development*, *35*(3), 911–935. https://doi.org/10.1007/s13593-014-0277-7

Bertham, Y. H., Aini, N., Gonggo Murcitro, B., & Dipo Nusantara, A. (2018). Uji Coba Empat Varietas Kedelai di Kawasan Pesisir Berbasis Biokompos. *Biogenesis: Jurnal Ilmiah Biologi*, *6*(1), 36–42. https://doi.org/10.24252/bio.v6i1.4144

Boote, K. J., Prasad, V., Allen, L. H., Singh, P., & Jones, J. W. (2018). Modeling sensitivity of grain yield to elevated temperature in the DSSAT crop models for peanut, soybean, dry bean, chickpea, sorghum, and millet. *European Journal of Agronomy*, *100*, 99–109. https://doi.org/10.1016/j.eja.2017.09.002

Bouchet, A. S., Laperche, A., Bissuel-Belaygue, C., Snowdon, R., Nesi, N., & Stahl, A. (2016). Nitrogen use efficiency in rapeseed. A review. *Agronomy for Sustainable Development*, *36*(2). https://doi.org/10.1007/s13593-016-0371-0

Boyd, E. S., & Peters, J. W. (2013). New insights into the evolutionary history of biological nitrogen fixation. *Frontiers in Microbiology*, *4*, 1–12. https://doi.org/10.3389/fmicb.2013.00201

Brooker, R. W., Bennett, A. E., Cong, W. F., Daniell, T. J., George, T. S., Hallett, P. D., Hawes, C., Iannetta, P. P. M., Jones, H. G., Karley, A. J., Li, L., Mckenzie, B. M., Pakeman, R. J., Paterson, E., Schöb, C., Shen, J., Squire, G., Watson, C. A., Zhang, C., … White, P. J. (2015). Improving intercropping: A synthesis of research in agronomy, plant physiology and ecology. *New Phytologist*, *206*, 107–117. https://doi.org/10.1111/nph.13132

Budiyanto, G. (2014). *Manajemen Sumber Daya Lahan*. LP3M UMY. http://repository.umy.ac.id/handle/123456789/6405

Caddel, J., Redfearn, D., & Edwards, J. (2017). Forage legumes and nitrogen production. *Oklohoma Cooperative Extension Service*, 1–6. http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-3101/PSS-2590web color.pdf

Cahyono. (2007). *Kedelai*. CV. Aneka Ilmu.

Canadell, P., Tian, H., Patra, P., & Thomson, R. (2019). *Nitrogen fertilisers are incredibly efficient, but they make climate change a lot worse*. https://theconversation.com/nitrogen-fertilisers-are-incredibly-efficient-but-they-make-climate-change-a-lot-worse-127103

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Carley, C. N., Zubrod, M. J., Dutta, S., & Singh, A. K. (2023). Using machine learning enabled phenotyping to characterize nodulation in three early vegetative stages in soybean. *Crop Science*, *63*(1), 204–226. https://doi.org/10.1002/csc2.20861

Carranca, C. (2014). *Legumes: Properties and symbiosis* (Issue January 2013).

Casal, J. J. (2012). Shade Avoidance. *The Arabidopsis Book*, *10*, e0157. https://doi.org/10.1199/tab.0157

Chang, X., Wei, D., Zeng, Y., Zhao, X., Hu, Y., Wu, X., Song, C., Gong, G., Chen, H., Yang, C., Zhang, M., Liu, T., Chen, W., & Yang, W. (2022). Maize-soybean relay strip intercropping reshapes the rhizosphere bacterial community and recruits beneficial bacteria to suppress Fusarium root rot of soybean. *Frontiers in Microbiology*, *13*, 1009689. https://doi.org/10.3389/fmicb.2022.1009689

Chang, X., Yan, L., Naeem, M., Khaskheli, M. I., Zhang, H., Gong, G., Zhang, M., Song, C., Yang, W., Liu, T., & Chen, W. (2020). Maize/soybean relay strip intercropping reduces the occurrence of fusarium root rot and changes the diversity of the pathogenic fusarium species. *Pathogens*, *9*(3), 211. https://doi.org/10.3390/pathogens9030211

Chapagain, T., & Riseman, A. (2014). Barley-pea intercropping: Effects on land productivity, carbon and nitrogen transformations. *Field Crops Research*, *166*, 18–25. https://doi.org/10.1016/j.fcr.2014.06.014

Chen, P., Du, Q., Liu, X., Zhou, L., Hussain, S., Lei, L., Song, C., Wang, X., Liu, W., Yang, F., Shu, K., Liu, J., Du, J., Yang, W., & Yong, T. (2017). Effects of reduced nitrogen inputs on crop yield and nitrogen use efficiency in a long-term maize-soybean relay strip intercropping system. *Plos One*, *12*(9), e0184503. https://doi.org/10.1371/journal.pone.0184503

Chen, P., Song, C., Liu, X. ming, Zhou, L., Yang, H., Zhang, X., Zhou, Y., Du, Q., Pang, T., Fu, Z. dan, Wang, X. chun, Liu, W. guo, Yang, F., Shu, K., Du, J., Liu, J., Yang, W., & Yong, T. (2019). Yield advantage and nitrogen fate in an additive maize-soybean relay intercropping system. *Science of the Total Environment*, *657*, 987–999. https://doi.org/10.1016/j.scitotenv.2018.11.376

Chen, X., Chen, J., & Cao, J. (2023). Intercropping increases soil N-targeting enzyme activities: A meta-analysis. *Rhizosphere*, *26*, 100686. https://doi.org/10.1016/j.rhisph.2023.100686

Cheng, B., Wang, L., Liu, R., Wang, W., Yu, R., Zhou, T., Ahmad, I., Raza, A., Jiang, S., Xu, M., Liu, C., Yu, L., Wang, W., Jing, S., Liu, W., & Yang, W. (2022). Shade-Tolerant Soybean Reduces Yield Loss by Regulating Its Canopy Structure and Stem Characteristics in the Maize–Soybean Strip Intercropping System. *Frontiers in Plant Science*, *13*(March), 1–16. https://doi.org/10.3389/fpls.2022.848893

Cheng, Z., Meng, L., Yin, T., Li, Y., Zhang, Y., & Li, S. (2023). Changes in Soil Rhizobia Diversity and Their Effects on the Symbiotic Efficiency of Soybean Intercropped with Maize. *Agronomy*, *13*(4). https://doi.org/10.3390/agronomy13040997

Ciampitti, I. A., de Borja Reis, A. F., Córdova, S. C., Castellano, M. J., Archontoulis, S. V., Correndo, A. A., Antunes De Almeida, L. F., & Moro Rosso, L. H. (2021). Revisiting biological nitrogen fixation dynamics in soybeans. *Frontiers in Plant Science*, *12*, 1–11. https://doi.org/10.3389/fpls.2021.727021

Cigelske, B. D., Kandel, H., & DeSutter, T. M. (2020). Soybean Nodulation and Plant Response to Nitrogen and Sulfur Fertilization in the Northern US. *Agricultural Sciences*, *11*(06), 592–607. https://doi.org/10.4236/as.2020.116037

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

De Costa, W. A. J. M., & Perera, M. K. K. W. (1998). Effects of bean population and row arrangement on the productivity of chilli/dwarf bean (Capsicum annuum/Phaseolus vulgaris L.) intercropping in Sri Lanka. *Journal of Agronomy and Crop Science*, *180*(1), 53–58. https://doi.org/10.1111/j.1439-037x.1998.tb00369.x

de Souza, C. H. E., Ribeiro, V. G. S., Goncalves, L. L., de Borba, M. G., & dos Anjos Reis, R. (2022). Phosphorus fertilizer with increased efficiency affects soybean yields. *Australian Journal of Crop Science*, *16*(7), 893–898. https://doi.org/10.21475/ajcs.22.16.07.p3538

Díaz-Pérez, J. C. (2013). Bell pepper (Capsicum annum L.) crop as affected by Shade level: Microenvironment, plant growth, leaf gas exchange, and leaf mineral nutrient concentration. *HortScience*, *48*(2), 175–182. https://doi.org/10.21273/hortsci.48.2.175

Distan Yogyakarta. (2009). *Standard operating procedure (SOP): Budidaya cabai merah Kulonprogo [Standard operating procedure (SOP): Red chili cultivation in Kulonprogo]*. Dinas Pertanian Daerah Istimewa Yogyakarta.

Du, Q., Chen, P., Zheng, B., Hu, Y., Yang, W., & Yong, T. (2022). Screening soybean for adaptation to relay intercropping systems: associations between reproductive organ abscission and yield. *Agronomy*, *12*(10), 2379. https://doi.org/10.3390/agronomy12102379

Du, Q., Zhou, L., Chen, P., Liu, X., Song, C., Yang, F., Wang, X., Liu, W., Sun, X., Du, J., Liu, J., Shu, K., Yang, W., & Yong, T. (2020). Relay-intercropping soybean with maize maintains soil fertility and increases nitrogen recovery efficiency by reducing nitrogen input. *The Crop Journal*, *8*(1), 140–152. https://doi.org/10.1016/j.cj.2019.06.010

Duchene, O., Vian, J. F., & Celette, F. (2017). Intercropping with legume for agroecological cropping systems: Complementarity and facilitation processes and the importance of soil microorganisms. A review. *Agriculture, Ecosystems & Environment*, *240*, 148–161. https://doi.org/10.1016/J.AGEE.2017.02.019

Ebbisa, A. (2022). Mechanisms underlying cereal/legume intercropping as nature-based biofortification: A review. In *Food Production, Processing and Nutrition* (Vol. 4, Issue 1). https://doi.org/10.1186/s43014-022-00096-y LK - https://doi.org/10.1186/s43014-022-00096-y

Elhady, A., Hallmann, J., & Heuer, H. (2020). Symbiosis of Soybean With Nitrogen Fixing Bacteria Affected by Root Lesion Nematodes in a Density-Dependent Manner. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-58546-x

Fageria, N. K., & Baligar, V. C. (2005). Enhancing Nitrogen Use Efficiency in Crop Plants. *Advances in Agronomy*, *88*(05), 97–185. https://doi.org/10.1016/S0065-2113(05)88004-6

Fan, Y., Chen, J., Cheng, Y., Raza, M. A., Wu, X., Wang, Z., Liu, Q., Wang, R., Wang, X., Yong, T., Liu, W., Liu, J., Du, J., Shu, K., Yang, W., & Yang, F. (2018). Effect of shading and light recovery on the growth, leaf structure, and photosynthetic performance of soybean in a maize-soybean relay-strip intercropping system. *PLoS ONE*, *13*(5), 1–15. https://doi.org/10.1371/journal.pone.0198159

Faozi, K., Yudono, P., Indradewa, D., & Maas, A. (2018). Banana stem bokashi and its effect to increase soybean yield (Glycine max L. Merrill) in coastal sands Area. *Agrotechnology*, *7*(2), 1–7. https://doi.org/10.4172/2168-9881.1000184

Fattah, A., Idaryani, Herniwati, Yasin, M., Suriani, S., Salim, Nappu, M. B., Mulia, S., Irawan Hannan, M. F., Wulanningtyas, H. S., Saenong, S., Dewayani, W., Suriany, Winanda, E., Manwan, S. W., Asaad, M., Warda, Nurjanani, Nurhafsah, … Ella, A. (2024).

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
Rohimah Handayani Sri Lestari, Dr. Ir. Endang Sulistyaningsih, M.Sc; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Pı
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Performance and morphology of several soybean varieties and responses to pests and diseases in South Sulawesi. *Heliyon*, *10*(5), e25507. https://doi.org/10.1016/j.heliyon.2024.e25507

Feng, L., Hu, Y., Shi, K., Tang, H., Pu, T., Wang, X., & Yang, W. (2024). Synergistic effects of crop aboveground growth and root traits guarantee stable yield of strip relay intercropping maize. *Agronomy*, *14*(3), 527. https://doi.org/10.3390/agronomy14030527 LK

Feng, L., Raza, M. A., Chen, Y., Khalid, M. H. Bin, Meraj, T. A., Ahsan, F., Fan, Y., Du, J., Wu, X., Song, C., Liu, C., Bawa, G., Zhang, Z., Yuan, S., Yang, F., & Yang, W. (2019). Narrow-wide row planting pattern improves the light environment and seed yields of intercrop species in relay intercropping system. *PLOS ONE*, *14*(2), e0212885. https://doi.org/10.1371/journal.pone.0212885

Feng, L., Yang, W., Zhou, Q., Tang, H., Ma, Q., Huang, G., & Wang, S. (2021). Effects of interspecific competition on crop yield and nitrogen utilisation in maize-soybean intercropping system. *Plant, Soil and Environment*, *67*(8), 460–467. https://doi.org/10.17221/665/2020-PSE

Franklin, K. A. (2008). Shade avoidance. *New Phytologist*, *179*(4), 930–944. https://doi.org/10.1111/j.1469-8137.2008.02507.x

Gecaitė, V., Arlauskienė, A., & Cesevičienė, J. (2021). Competition Effects and Productivity in Oat–Forage Legume Relay Intercropping Systems under Organic Farming Conditions. *Agriculture*, *11*(2), 99. https://doi.org/10.3390/agriculture11020099

Gitari, H. I., Karanja, N. N., Gachene, C. K. K., Kamau, S., Sharma, K., & Schulte-Geldermann, E. (2018). Nitrogen and phosphorous uptake by potato (Solanum tuberosum L.) and their use efficiency under potato-legume intercropping systems. *Field Crops Research*, *222*, 78–84. https://doi.org/10.1016/j.fcr.2018.03.019

Glaze-Corcoran, S., Hashemi, M., Sadeghpour, A., Jahanzad, E., Keshavarz Afshar, R., Liu, X., & Herbert, S. J. (2020). Understanding intercropping to improve agricultural resiliency and environmental sustainability. In *Advances in Agronomy* (1st ed., Vol. 162, pp. 199–256). Elsevier Inc. https://doi.org/10.1016/bs.agron.2020.02.004

Goh, C. H., Nicotra, A. B., & Mathesius, U. (2019). Genes controlling legume nodule numbers affect phenotypic plasticity responses to nitrogen in the presence and absence of rhizobia. *Plant Cell and Environment*, *42*(5), 1747–1757. https://doi.org/10.1111/pce.13498

Gommers, C. M. M., Visser, E. J. W., Onge, K. R. S., Voesenek, L. A. C. J., & Pierik, R. (2013). Shade tolerance: when growing tall is not an option. *Trends in Plant Science*, *18*(2), 65–71. https://doi.org/10.1016/j.tplants.2012.09.008

Gong, W. Z., Jiang, C. D., Wu, Y. S., Chen, H. H., Liu, W. Y., & Yang, W. Y. (2015). Tolerance vs. avoidance: two strategies of soybean (Glycine max) seedlings in response to shade in intercropping. *Photosynthetica*, *53*(2), 259–268. https://doi.org/10.1007/s11099-015-0103-8

Govindasamy, P., Muthusamy, S. K., Bagavathiannan, M., Mowrer, J., Jagannadham, P. T. K., Maity, A., Halli, H. M., G. K, S., Vadivel, R., T. K, D., Raj, R., Pooniya, V., Babu, S., Rathore, S. S., L, M., & Tiwari, G. (2023). Nitrogen use efficiency—a key to enhance crop productivity under a changing climate. *Frontiers in Plant Science*, *14*(3), 1–19. https://doi.org/10.3389/fpls.2023.1121073

Handriawan, A., Respatie, D. W., & Tohari. (2017). Pengaruh intensitas naungan terhadap pertumbuhan dan hasil tiga kultivar kedelai (Glycine max (L.) Merrill) di lahan pasir

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

pantai Bugel, Kulon Progo [Effect of shade intensity on growth and yield of three soybean (Glycine max (L.) Merrill) cultivars on co. *Vegetalika*, *5*(3), 1–14. https://doi.org/10.22146/veg.25346

Hani, A. (2015). Produktivitas Kedelai pada Pola Agroforestri Nyamplung (Callophylum inophylum) di Lahan Berpasir Pangandaran, Jawa Barat. *Jurnal Silvikultur Tropika*, *06*(2), 78–82.

Hassan, A., Dresbøll, D. B., Rasmussen, C. R., Lyhne-Kjærbye, A., Nicolaisen, M. H., Stokholm, M. S., Lund, O. S., & Thorup-Kristensen, K. (2021). Root distribution in intercropping systems–a comparison of DNA based methods and visual distinction of roots. *Archives of Agronomy and Soil Science*, *67*(1), 15–28. https://doi.org/10.1080/03650340.2019.1675872

He, Z. Q., Zhuang, J., Tang, H. R., & Huang, Z. (2012). Different vegetables crops in response to allelopathic of hot pepper root exudates. *World Applied Sciences Journal*, *19*(9), 1289–1294. https://doi.org/10.5829/idosi.wasj.2012.19.09.1886

Herawati, A., Mujiyo, Herdiansyah, G., Syamsiyah, J., & Lestari, A. (2023). Automasi irigasi di lahan pasir pantai untuk meningkatkan produktivitas tanaman budidaya. *Jurnal Sains Dan Teknologi*, *12*(3), 572–582. https://doi.org/10.23887/jstundiksha.v12i3.56096

Herlina, N., Hariyono, D., & Tri Margawati, D. (2017). Pengaruh Waktu Tanam Kubis (Brasssica oleraceae L. var capitata) dan Cabai (Capsicum annum L.) Terhadap Efisiensi Penggunaan Lahan Pada Sistem Tumpangsari. *Jurnal Hortikultura Indonesia*, *8*(2), 111. https://doi.org/10.29244/jhi.8.2.111-119

Ho, R., Mo, O., Ti, O., & Ra, A. (2022). Cowpea Vigna unguiculata (L.) walp and chilli pepper Capsicum frutescens (L.) intercropping as affected by planting pattern and insect pest management in the rain forest area of Nigeria. *Journal of Entomology and Zoology Studies*, *10*(2), 01–07. https://doi.org/10.22271/j.ento.2022.v10.i2a.8960

Homulle, Z., George, T. S., & Karley, A. J. (2022). Root traits with team benefits: understanding belowground interactions in intercropping systems. *Plant and Soil*, *471*(1–2), 1–26. https://doi.org/10.1007/s11104-021-05165-8

Houlton, B. Z., Almaraz, M., Aneja, V., Austin, A. T., Bai, E., Cassman, K. G., Compton, J. E., Davidson, E. A., Erisman, J. W., Galloway, J. N., Gu, B., Yao, G., Martinelli, L. A., Scow, K., Schlesinger, W. H., Tomich, T. P., Wang, C., & Zhang, X. (2019). A World of Cobenefits: Solving the Global Nitrogen Challenge. *Earth's Future*, *7*(8), 865–872. https://doi.org/10.1029/2019EF001222

Ibrahim Abdel-Wahab, T. (2016). Response of Some Soybean Cultivars to Low Light Intensity under Different Intercropping Patterns with Maize. *International Journal of Applied Agricultural Sciences*, *2*(2), 21. https://doi.org/10.11648/j.ijaas.20160202.11

Indradewa, D. (2021). Potensi lahan pasir pantai sebagai lahan pertanian produktif [Potential of coastal sandy land as productive agricultural land]. In D. Indradewa, S. N. H. Utami, V. D. S. Handayani, & S. N. R. Irwan (Eds.), *Inovasi teknologi agronomi di lahan pasir pantai [Innovations in agronomic technology on coastal sandy land]* (pp. 1–30). Deepublish.

Iqbal, N., Fatma, M., Gautam, H., Sehar, Z., Rasheed, F., Khan, M. I. R., Sofo, A., & Khan, N. A. (2022). Salicylic Acid Increases Photosynthesis of Drought Grown Mustard Plants Effectively with Sufficient-N via Regulation of Ethylene, Abscisic Acid, and Nitrogen-Use Efficiency. *Journal of Plant Growth Regulation*, *41*(5), 1966–1977. https://doi.org/10.1007/s00344-021-10565-2

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Istiyanti, E., Khasanah, U., & Anjarwati, A. (2015). Pengembangan usahatani cabai merah di lahan pasir pantai kecamatan Temon Kabupaten Kulonprogo [Development of red chilli farming in coastal land of Temon, Kulonprogo]. *Agraris: Journal of Agribusiness and Rural Development Research*, *1*(1), 6–11. https://doi.org/10.18196/agr.112

Jensen, E. S., Carlsson, G., & Hauggaard-Nielsen, H. (2020). Intercropping of grain legumes and cereals improves the use of soil N resources and reduces the requirement for synthetic fertilizer N: a global-scale analysis. *Agronomy for Sustainable Development*, *40*, 5. https://doi.org/10.1007/s13593-020-0607-x

Jensen, E. S., Chongtham, I. R., Dhamala, N. R., Rodriguez, C., Carton, N., & Carlsson, G. (2020). Diversifying European agricultural systems by intercropping. *International Journal of Agriculture and Natural Resources*, *47*(3), 174–186. https://doi.org/10.7764/ijanr.v47i3.2241

Jumrani, K., Bhatia, V. S., Hussain, S., Kataria, S., Yang, X., & Brestic, M. (2024). Effect of shading on leaf anatomical structure, photosynthesis characteristics and chlorophyll fluorescence of soybean (Glycine max). *Journal of Agronomy and Crop Science*, *210*(e12783). https://doi.org/10.1111/jac.12783

Kebede, E. (2021). Contribution, Utilization, and Improvement of Legumes-Driven Biological Nitrogen Fixation in Agricultural Systems. *Frontiers in Sustainable Food Systems*, *5*(November), 1–18. https://doi.org/10.3389/fsufs.2021.767998

Kertonegoro, B. D. (2001). Gumuk Pasir Pantai di D.I. Yogyakarta : Potensi dan Pemanfaatannya Untuk Pertanian Berkelanjutan. *Prosiding Seminar Nasional Pemanfaatan Sumberdaya Lokal Untuk Pembangunan Pertanian Berkelanjutan*, 46–54.

Khalid, M. H. B., Raza, M. A., Yu, H. Q., Sun, F. A., Zhang, Y. Y., Lu, F. Z., Si, L., Iqbal, N., Khan, I., Fu, F. L., & Li, W. C. (2019). Effect of shade treatments on morphology, photosynthetic and chlorophyll fluorescence characteristics of soybeans (Glycine max L. Merr.). *Applied Ecology and Environmental Research*, *17*(2), 2551–2569. https://doi.org/10.15666/aeer/1702_25512569

Kim, J., Song, Y., Kim, D. W., Fiaz, M., & Kwon, C. H. (2017). Enhancing Yield and Nutritive Value of Forage for Livestock Feeding Through Corn Soybean Intercropping Strategy with Several Pre-sowing Soybean Seed Coatings. *Journal of The Korean Society of Grassland and Forage Science*, *37*(1), 50–55. https://doi.org/10.5333/KGFS.2017.37.1.50

Klimek-Kopyra, A., Bacior, M., Lorenc-Kozik, A., Neugschwandtner, R. W., & Zając, T. (2020). The Intraspecific competition as a driver for true production potential of soybean. *Italian Journal of Agronomy*, *16*(1), 1709. https://doi.org/10.4081/ija.2020.1709

Kosslak, R. M., & Bohlool, B. Ben. (1984). Suppression of Nodule Development of One Side of a Split-Root System of Soybeans Caused by Prior Inoculation of the Other Side. *Plant Physiology*, *75*(1), 125–130. https://doi.org/10.1104/pp.75.1.125

Larcher, W. (2003). Physiological Plant Ecology. In *Physiological Plant Ecology* (Fourth). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-05214-3

Latati, M., Benlahrech, S., Lazali, M., Sihem, T., Kaci, G., Takouachet, R., Alkama, N., Hamdani, F. Z., Hafnaoui, E. A., Belarbi, B., Ounane, G., & Ounane, S. M. (2016). Intercropping Promotes the Ability of Legume and Cereal to Facilitate Phosphorus and Nitrogen Acquisition through Root- Induced Processes. In *Grain Legumes* (pp. 127–139). https://doi.org/10.5772/63438

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Lawson, T., & Matthews, J. (2020). Guard Cell Metabolism and Stomatal Function. *Annual Review of Plant Biology*, *71*, 273–302. https://doi.org/10.1146/annurev-arplant-050718-100251

Legba, E. C., Dossou, L., Honfoga, J., Pawera, L., & Srinivasan, R. (2025). Productivity and Profitability of Maize-Mungbean and Maize-Chili Pepper Relay Intercropping Systems for Income Diversification and Soil Fertility in Southern Benin. *Sustainability (Switzerland)*, *17*(3). https://doi.org/10.3390/su17031076

Li, C., Hoffland, E., Kuyper, T. W., Yu, Y., Zhang, C., Li, H., Zhang, F., & van der Werf, W. (2020). Syndromes of production in intercropping impact yield gains. *Nature Plants*, *6*(6), 653–660. https://doi.org/10.1038/s41477-020-0680-9

Li, L., Li, S. M., Sun, J. H., Zhou, L. L., Bao, X. G., Zhang, H. G., & Zhang, F. S. (2007). Diversity enhances agricultural productivity via rhizosphere phosphorus facilitation on phosphorus-deficient soils. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(27), 11192–11196. https://doi.org/10.1073/pnas.0704591104

Li, L., Tilman, D., Lambers, H., & Zhang, F. S. (2014). Plant diversity and overyielding: Insights from belowground facilitation of intercropping in agriculture. *New Phytologist*, *203*(1), 63–69. https://doi.org/10.1111/nph.12778

Liang, Y., Liu, Q., Zeng, J., Xiong, F., Guo, J., Li, G., & Lu, D. (2024). Optimizing Nitrogen Input Increased Yield and Efficiency in Maize-Soybean Strip Intercropping System. *Agronomy*, *14*(11). https://doi.org/10.3390/agronomy14112472

Liao, C., Fang, S., Zhang, H., Liu, L., Xie, J., Li, X., Cao, F., Chen, J., & Huang, M. (2024). Grain Yield and Yield Attributes of Currently Popular Hybrid Rice Varieties Compared to Representative Super Hybrid Rice Varieties in Subtropical Environments. *Agronomy*, *14*(318). https://doi.org/10.3390/agronomy14020318

Lin, P., Wang, J., Chen, P., Fu, Z., Luo, K., Li, Y., Pu, T., Wang, X., Yong, T., & Yang, W. (2024). Relay intercropped soybean promotes nodules development and nitrogen fixation by root exudates deposition. *Frontiers in Plant Science*, *15*. https://doi.org/10.3389/fpls.2024.1447447

Liu, B., Gao, P., & Zhang, S. (2022). Photosynthesis and Fine Root Growth Dynamics of Soybean in Walnut-Soybean Agroforestry System. *Computational Intelligence and Neuroscience*, *2022*(1), 1–8. https://doi.org/10.1155/2022/2246824

Liu, C., Tu, B., Li, Y., Tian, B., Zhang, Q., Liu, X., & Herbert, S. J. (2017). Potassium application affects key enzyme activities of sucrose metabolism during seed filling in vegetable soybean. *Crop Science*, *57*(5), 2707–2717. https://doi.org/10.2135/cropsci2016.08.0648

Liu, L., Knight, J. D., Lemke, R. L., & Farrell, R. E. (2024). Quantifying the contribution of above- and below-ground residues of chickpea, faba bean, lentil, field pea and wheat to the nitrogen nutrition of a subsequent wheat crop. *Field Crops Research*, *313*, 109412. https://doi.org/10.1016/j.fcr.2024.109412

Liu, R., Zhou, G. peng, Cang, D. na, Gao, S. juan, Han, M., Zhang, J. dong, Sun, X. feng, & Cao, W. dong. (2022). Transfer characteristics of nitrogen fixed by leguminous green manure crops when intercropped with maize in northwestern China. *Journal of Integrative Agriculture*, *21*(4), 1177–1187. https://doi.org/10.1016/S2095-3119(21)63674-2

Liu, S., Wang, L., Chang, L., Khan, I., Nadeem, F., Rehman, A., & Suo, R. (2023). Evaluating the influence of straw mulching and intercropping on nitrogen uptake, crop

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

growth, and yield performance in maize and soybean. *Frontiers in Plant Science*, *14*. https://doi.org/10.3389/fpls.2023.1280382

Liu, X., Meng, L., Yin, T., Wang, X., Zhang, S., Cheng, Z., Ogundeji, A. O., & Li, S. (2023). Maize/soybean intercrop over time has higher yield stability relative to matched monoculture under different nitrogen-application rates. *Field Crops Research*, *301*, 109015. https://doi.org/10.1016/j.fcr.2023.109015

Liu, X., Rahman, T., Song, C., Su, B., Yang, F., Yong, T., Wu, Y., Zhang, C., & Yang, W. (2017). Changes in light environment, morphology, growth and yield of soybean in maize-soybean intercropping systems. *Field Crops Research*, *200*, 38–46. https://doi.org/10.1016/j.fcr.2016.10.003

Liu, X., Rahman, T., Yang, F., Song, C., Yong, T., Liu, J., Zhang, C., & Yang, W. (2017). PAR Interception and Utilization in Different Maize and Soybean Intercropping Patterns. *PLOS ONE*, *12*(1), e0169218. https://doi.org/10.1371/journal.pone.0169218

Lo Presti, E., Kavamura, V. N., Abadie, M., Romeo, M., Reid, T. E., Heuer, S., Monti, M., & Mauchline, T. H. (2024). Phosphorus availability drives the effect of legume-wheat intercropping on prokaryotic community interactions. *Applied Soil Ecology*, *199*, 105414. https://doi.org/10.1016/j.apsoil.2024.105414

Long, G., Li, L., Wang, D., Zhao, P., Tang, L., Zhou, Y., & Yin, X. (2021). Nitrogen levels regulate intercropping-related mitigation of potential nitrate leaching. *Agriculture, Ecosystems & Environment*, *319*, 107540. https://doi.org/10.1016/j.agee.2021.107540

Lopes, E. C. S., Rodrigues, W. P., Fraga, K. R., Filho, J. A. M., da Silva, J. R., de Assis-Gomes, M. M., Figueiredo, F. A. M. M. A., Gresshoff, P. M., & Campostrini, E. (2019). Hypernodulating soybean mutant line nod4 lacking 'Autoregulation of Nodulation' (AON) has limited root-to-shoot water transport capacity. *Annals of Botany*, *124*(6), 979–991. https://doi.org/10.1093/aob/mcz040

Luo, C., Guo, Z., Xiao, J., Dong, K., & Dong, Y. (2021). Effects of Applied Ratio of Nitrogen on the Light Environment in the Canopy and Growth, Development and Yield of Wheat When Intercropped. *Frontiers in Plant Science*, *12*, 1–12. https://doi.org/10.3389/fpls.2021.719850

Lv, Q., Dai, J., Ding, K., He, N., Li, Z., Zhang, D., Xu, S., Li, C., Chi, B., Zhang, Y., & Dong, H. (2024). Managing interspecific competition to enhance productivity through selection of soybean varieties and sowing dates in a cotton-soybean intercropping system. *Field Crops Research*, *316*, 109513. https://doi.org/10.1016/j.fcr.2024.109513

Mahmud, K., Makaju, S., Ibrahim, R., & Missaoui, A. (2020). Current progress in nitrogen fixing plants and microbiome research. *Plants*, *9*(1), 1–17. https://doi.org/10.3390/plants9010097

Mahmud, K., Panday, D., Mergoum, A., & Missaoui, A. (2021). Nitrogen losses and potential mitigation strategies for a sustainable agroecosystem. *Sustainability (Switzerland)*, *13*(4), 1–23. https://doi.org/10.3390/su13042400

Mao, L. L., Zhang, L. Z., Zhang, S. P., Evers, J. B., van der Werf, W., Wang, J. J., Sun, H. Q., Su, Z. C., & Spiertz, H. (2015). Resource use efficiency, ecological intensification and sustainability of intercropping systems. *Journal of Integrative Agriculture*, *14*(8), 1542–1550. https://doi.org/10.1016/S2095-3119(15)61039-5

Marschner, P. (2012). Marschner's Mineral Nutrition of Higher Plants: Third Edition. In *Marschner's Mineral Nutrition of Higher Plants: Third Edition*. Elsevier Inc. https://doi.org/10.1016/C2009-0-63043-9

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Martínez-Dalmau, J., Berbel, J., & Ordóñez-Fernández, R. (2021). Nitrogen fertilization. A review of the risks associated with the inefficiency of its use and policy responses. *Sustainability (Switzerland)*, *13*(10), 1–15. https://doi.org/10.3390/su13105625

Matimati, I., Anthony Verboom, G., & Cramer, M. D. (2014). Do hydraulic redistribution and nocturnal transpiration facilitate nutrient acquisition in Aspalathus linearis? *Oecologia*, *175*(4), 1129–1142. https://doi.org/10.1007/s00442-014-2987-6

Mead, R., & Willey, R. W. (1980). The concept of a 'land equivalent ratio' and advantages in yields from intercropping. *Experimental Agriculture*, *16*(3), 217–228. https://doi.org/10.1017/S0014479700010978

Meinarti, N. S., & Jauhari, S. (2008). Penerapan Irigasi Mikro, Tumpangsari Dan Mulsa Untuk Mengantisipasi Kehilangan Hasil Cabai Merah Pada Penanaman Di Musim Kemarau. *Jurnal Agromet Indonesia*, *22*(1), 13–21.

Meitasari, A. D., & Wicaksono, K. P. (2017). Inokulasi rhizobium dan perimbangan nitrogen pada tanaman kedelai (Glycine max (l) merrill) varietas Wilis. *Plantropica Journal of Agricultural Science*, *2*(1), 55–63.

Mndzebele, B., Ncube, B., Fessehazion, M., Mabhaudhi, T., Amoo, S., du Plooy, C., Venter, S., & Modi, A. (2020). Effects of cowpea-amaranth intercropping and fertiliser application on soil phosphatase activities, available soil phosphorus, and crop growth response. *Agronomy*, *10*(1). https://doi.org/10.3390/agronomy10010079

Moekasan, T. K., & Prabaningrum, L. (2012). Penggunaan Rumah Kasa untuk Mengatasi Serangan Organisme Pengganggu Tumbuhan pada Tanaman Cabai Merah di Dataran Rendah. *Jurnal Hortikultura*, *22*(1), 66. https://doi.org/10.21082/jhort.v22n1.2012.p65-75

Mu, X., & Chen, Y. (2021). The physiological response of photosynthesis to nitrogen deficiency. *Plant Physiology and Biochemistry*, *158*, 76–82. https://doi.org/10.1016/j.plaphy.2020.11.019

Munawar. (2011). *Kesuburan Tanah dan Nutrisi Tanaman*. IPB Pres.

Munawaroh, L., Kalsum, U., Laksono, P. B., & Siallagan, I. (2018). Respon Tanaman Kedelai Varietas Ceneng Pada Intensitas Cahaya Berbeda. *Jurnal Pertanian Presisi (Journal of Precision Agriculture)*, *2*(2), 98–112. https://doi.org/10.35760/jpp.2018.v2i2.2669

Munda, E. (2017). Effect of intercropping and phosphorous application on the growth and yield of sweetpotato, groundnut and soybean. In *Stellenbosch University*. Stellenbosch University.

Nasar, J., Wang, G. Y., Zhou, F. J., Gitari, H., Zhou, X. B., Tabl, K. M., Hasan, M. E., Ali, H., Waqas, M. M., Ali, I., & Jahan, M. S. (2022). Nitrogen fertilization coupled with foliar application of iron and molybdenum improves shade tolerance of soybean under maize-soybean intercropping. *Frontiers in Plant Science*, *13*. https://doi.org/10.3389/fpls.2022.1014640

Nasar, J., Zhao, C. J., Khan, R., Gul, H., Gitari, H., Shao, Z., Abbas, G., Haider, I., Iqbal, Z., Ahmed, W., Rehman, R., Liang, Q. P., Zhou, X. B., & Yang, J. (2023). Maize-soybean intercropping at optimal N fertilization increases the N uptake, N yield and N use efficiency of maize crop by regulating the N assimilatory enzymes. *Frontiers in Plant Science*, *13*. https://doi.org/10.3389/fpls.2022.1077948

Ngwenya, Z. D., Mohammed, M., & Dakora, F. D. (2024). Monocropping and Intercropping of Maize with Six Food Legumes at Malkerns in Eswatini: Their Effects on Plant

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Growth, Grain Yield and N2 Fixation, Measured using the 15N Natural Abundance and Ureide Techniques. *Symbiosis*, *92*(2), 257–269. https://doi.org/10.1007/s13199-024-00971-x

Ningrum, S. M., Tohari, T., & Respatie, D. W. (2020). Pengaruh Tingkat Naungan dan Takaran Pupuk Kandang Kambing Etawa terhadap Pertumbuhan dan Hasil Kedelai (*Glycine max* (L.) Merrill) di Lahan Pasir Pantai. *Vegetalika*, *9*(2), 373. https://doi.org/10.22146/veg.34876

Nugroho, N. C., & Caturatmi, A. (2017). Inovasi spesifik lokasi dalam pengembangan lahan pasir pantai sebagai lahan pertanian. *Prosiding Seminar Nasional Mewujudkan Kedaulatan Pangan Pada Lahan Sub Optimal Melalui Inovasi Teknologi Pertanian Spesifik Lokasi*, *1*, 264–268.

Ofori, F., & Stern, W. R. (1987). Cereal–Legume Intercropping Systems. *Advances in Agronomy*, *41*, 41–90. https://doi.org/10.1016/S0065-2113(08)60802-0

Omollo, J., Semu, E., Msaky, J., & Owuor, P. (2016). Effects of Lime and Nitrogen on Properties of an Acidic Soil and Nutrient Content of Sugarcane under Sugarcane – Soybean Intercropping in Kenya. *American Journal of Experimental Agriculture*, *13*(6), 1–15. https://doi.org/10.9734/AJEA/2016/28153

Partoyo. (2005). Analisis Indeks Kualitas Tanah Pertanian Di Lahan Pasir Pantai Samas Yogyakarta Analysis of Soil Quality Index for Sand Dune Agriculture Land At Samas Yogyakarta. *Agricultural Science (Ilmu Pertanian)*, *12*(2), 140–151. http://eprints.upnyk.ac.id/13510/1/Partoyo%2C 2005_Indeks Kualitas Tanah Samas_Ilmu Pertanian_Vol 12 No 2_140-151%281%29.pdf%0Ahttp://agrisci.ugm.ac.id/vol12_2.htm

Pelzer, E., Hombert, N., Jeuffroy, M. H., & Makowski, D. (2014). Meta-analysis of the effect of nitrogen fertilization on annual cereal–legume intercrop production. *Agronomy Journal*, *106*(5), 1775–1786. https://doi.org/10.2134/agronj13.0590

Pemkab Bantul. (2021). *RPJMD Kabupaten Bantul 2021-2026*. Pemkab Bantul.

Peng, X., Thevathasan, N. V, Gordon, A. M., Mohammed, I., & Gao, P. (2015). Photosynthetic Response of Soybean to Microclimate in 26-Year-Old Tree-Based Intercropping Systems in Southern Ontario, Canada. *PLOS ONE*, *10*(6), e0129467. https://doi.org/10.1371/journal.pone.0129467

Permanasari, I., Sulistyaningsih, E., Kurniasih, B., & Indradewa, D. (2021). Soybean varieties tolerance to intercropping with maize. *IOP Conference Series: Earth and Environmental Science*, *883*(1), 012033. https://doi.org/10.1088/1755-1315/883/1/012033

Permanasari, I., Sulistyaningsih, E., Kurniasih, B., & Indradewa, D. (2023). Morphophysiological and yield traits of soybean varieties tolerant of intercropping with maize. *Biodiversitas*, *24*(7), 3872–3880. https://doi.org/10.13057/biodiv/d240726

Pierozan Junior, C., Favarin, J. L., Lago, B. C., de Almeida, R. E. M., de Oliveira, S. M., Trivelin, P. C. O., Oliveira, F. B., & Gilabel, A. P. (2020). Nitrogen Fertilizer Recovery and Partitioning Related to Soybean Yield. *Journal of Soil Science and Plant Nutrition*, *20*(4), 2566–2578. https://doi.org/10.1007/s42729-020-00322-x

Poorter, H., Niklas, K. J., Reich, P. B., Oleksyn, J., Poot, P., & Mommer, L. (2012). Biomass allocation to leaves, stems and roots: Meta-analyses of interspecific variation and environmental control. *New Phytologist*, *193*(1), 30–50. https://doi.org/10.1111/j.1469-8137.2011.03952.x

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Prabawardani, S., Puadi, L., Noya, A. I., & Syaranamual, S. (2021). Respon Pertumbuhan dan Hasil Jagung (Zea mays L.) Dalam Sistem Tumpangsari dengan Beberapa Jenis Tanaman Semusim. *Peningkatan Produktivitas Pertanian Era Society 5.0 Pasca Pandemi*, 121–132. https://doi.org/10.25047/agropross.2021.214

Prasetyo, T., Subagiono, & Hasnelly. (2020). Produktivitas tanaman cabai rawit (Capsicum Frutescens L) dalam pola tumpangsari cabai dan jenis legum Triman. *Jurnal Sains Agro*, *9*(2), 117–126.

Pratiwi, H., & Artari, D. R. (2018). Respon Morfo-Fisiologi Genotipe Kedelai terhadap Naungan Jagung dan Ubikayu. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *46*(1), 48. https://doi.org/10.24831/jai.v46i1.15441

Pratiwi, H., & Purwaningrahayu, R. D. (2021). Potensi Hasil Kedelai sebagai Tanaman Sela pada Pertanaman Cabai Rawit. *Proceedings Series on Physical & Formal Sciences*, *2*, 124–130. https://doi.org/10.30595/pspfs.v2i.180

Purnamasari, E. T., Yudono, P., & Rogomulyo, R. (2016). Pertumbuhan gulma dan hasil kedelai hitam (Glycine max (L.) Merrill) 'Mallika' terhadap pengolahan tanah dan jarak tanam di lahan pasir pantai [The weeds growth and yield of 'Mallika' black soybean (Glycine max (L .) Merrill) against to tillage and spac. *Vegetalika*, *5*(1), 23–31. https://doi.org/10.22146/VEG.24652

Pusdatin. (2024). *Analisis kinerja perdagangan kedelai*. Pusat Data dan Sistem Informasi Pertanian Kementerian Pertanian.

Putra, F. P., Yudono, P., & Waluyo, S. (2018). Perubahan komposisi gulma pada sistem tumpangsari padi gogo dengan kedelai di lahan pasir pantai [Weeds composition change under intercropping system of upland rice with soybean in coastal sandy Area]. *Jurnal Agronomi Indonesia*, *46*(1), 33–39. https://doi.org/10.24831/jai.v46i1.17093

Putra, S. S., Putra, E. T. S., & Widada, J. (2020). The effects of types of manure and mycorrhizal applications on sandy soils on the growth and yield of curly red chili (Capsicum annum L.). *Caraka Tani: Journal of Sustainable Agriculture*, *35*(2), 258–267. https://doi.org/10.20961/carakatani.v35i2.34971

Putra, T. K., Afany, M. R., & Widodo, R. A. (2020). Pengaruh Bahan Organik Dan Tanah Vertisol Sebagai Pembenah Tanah Terhadap Ketersediaan Dan Pelindian Kalium Di Tanah Regosol Pasir Pantai. *Tanah Dan Air*, *17*(1), 20–25. https://doi.org/10.31315/jta.v17i1.4007

Qin, H., Ma, Q., Chen, Y., Tian, B., Xu, L., Bai, Y., Chen, W., & Li, X. (2020). Variation in Rhizosphere Microbial Communities and Its Association With the Symbiotic Efficiency of Rhizobia in Soybean. *The Isme Journal*, *14*(8), 1915–1928. https://doi.org/10.1038/s41396-020-0648-9

Querejeta, J. I., Prieto, I., Armas, C., Casanoves, F., Diémé, J. S., Diouf, M., Yossi, H., Kaya, B., Pugnaire, F. I., & Rusch, G. M. (2022). Higher leaf nitrogen content is linked to tighter stomatal regulation of transpiration and more efficient water use across dryland trees. *New Phytologist*, *235*(4), 1351–1364. https://doi.org/10.1111/nph.18254

Rahman, T., Ye, L., Liu, X., Iqbal, N., Du, J., Gao, R., Liu, W., Yang, F., & Yang, W. (2017). Water use efficiency and water distribution response to different planting patterns in maize–soybean relay strip intercropping systems. *Experimental Agriculture*, *53*(2), 159–177. https://doi.org/10.1017/S0014479716000260

Rajiman. (2014). Pengaruh Bahan Pembenah Tanah di Lahan Pasir Pantai Terhadap Kualitas Tanah. *Prosiding Seminar Nasional Lahan Suboptimal 2014*.

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
Rohimah Handayani Sri Lestari, Dr. Ir. Endang Sulistyaningsih, M.Sc; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Pı
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Rasmussen, J., Gylfadóttir, T., Loges, R., Eriksen, J., & Helgadóttir, Á. (2013). Spatial and temporal variation in N transfer in grass-white clover mixtures at three Northern European field sites. *Soil Biology and Biochemistry*, *57*, 654–662. https://doi.org/10.1016/j.soilbio.2012.07.004

Raza, A., Asghar, M. A., Ahmad, B., Bin, C., Iftikhar Hussain, M., Li, W., Iqbal, T., Yaseen, M., Shafiq, I., Yi, Z., Ahmad, I., Yang, W., & Weiguo, L. (2020). Agro-Techniques for Lodging Stress Management in Maize-Soybean Intercropping System—A Review. *Plants*, *9*(11), 1592. https://doi.org/10.3390/plants9111592

Raza, M. A., Bin Khalid, M. H., Zhang, X., Feng, L. Y., Khan, I., Hassan, M. J., Ahmed, M., Ansar, M., Chen, Y. K., Fan, Y. F., Yang, F., & Yang, W. (2019). Effect of planting patterns on yield, nutrient accumulation and distribution in maize and soybean under relay intercropping systems. *Scientific Reports*, *9*, 4947. https://doi.org/10.1038/s41598-019-41364-1

Raza, M. A., Din, A. M. U., Zhiqi, W., Gul, H., Ur Rehman, S., Bukhari, B., Haider, I., Rahman, M. H. U., Liang, X., Luo, S., El Sabagh, A., Qin, R., & Zhongming, M. (2023). Spatial differences influence nitrogen uptake, grain yield, and land-use advantage of wheat/soybean relay intercropping systems. *Scientific Reports*, *13*, 16916. https://doi.org/10.1038/s41598-023-43288-3

Raza, M. A., Feng, L. Y., Iqbal, N., Ahmed, M., Chen, Y. K., Khalid, M. H. Bin, Mohi Ud Din, A., Khan, A., Ijaz, W., Hussain, A., Jamil, M. A., Naeem, M., Bhutto, S. H., Ansar, M., Yang, F., & Yang, W. (2019). Growth and development of soybean under changing light environments in relay intercropping system. *PeerJ*, *7*, e7262. https://doi.org/10.7717/peerj.7262

Raza, M. A., Feng, L. Y., van der Werf, W., Cai, G. R., Khalid, M. H. Bin, Iqbal, N., Hassan, M. J., Meraj, T. A., Naeem, M., Khan, I., Rehman, S. ur, Ansar, M., Ahmed, M., Yang, F., & Yang, W. (2019). Narrow-Wide-Row Planting Pattern Increases The Radiation Use Efficiency and Seed Yield of Intercrop Species in Relay-Intercropping System. *Food and Energy Security*, *8*(3), 1–12. https://doi.org/10.1002/fes3.170

Raza, M. A., Gul, H., Wang, J., Yasin, H. S., Qin, R., Bin Khalid, M. H., Naeem, M., Feng, L. Y., Iqbal, N., Gitari, H., Ahmad, S., Battaglia, M., Ansar, M., Yang, F., & Yang, W. (2021). Land productivity and water use efficiency of maize-soybean strip intercropping systems in semi-arid areas: A case study in Punjab Province, Pakistan. *Journal of Cleaner Production*, *308*, 127282. https://doi.org/10.1016/j.jclepro.2021.127282

Richards, J. H., & Caldwell, M. M. (1987). Hydraulic lift: Substantial nocturnal water transport between soil layers by Artemisia tridentata roots. *Oecologia*, *73*(4), 486–489. https://doi.org/10.1007/BF00379405

Richardson, A. E., Hocking, P. J., Simpson, R. J., & George, T. S. (2009). Plant mechanisms to optimise access to soil phosphorus. *Crop and Pasture Science*, *60*(2), 124–143. https://doi.org/10.1071/CP07125

Rodriguez, C., Carlsson, G., Englund, J.-E., Flöhr, A., Pelzer, E., Jeuffroy, M.-H., Makowski, D., & Jensen, E. S. (2020). Grain legume-cereal intercropping enhances the use of soil-derived and biologically fixed nitrogen in temperate agroecosystems. A meta-analysis. *European Journal of Agronomy*, *118*, 126077. https://doi.org/10.1016/j.eja.2020.126077

Römheld, V., & Kirkby, E. A. (2010). Research on potassium in agriculture: Needs and prospects. *Plant and Soil*, *335*(1), 155–180. https://doi.org/10.1007/S11104-010-0520-1

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Sai, E. J., . R., & Kumari, M. S. (2024). Maximizing Water Use Efficiency (WUE), Land Utilization Efficiency (LUE) and Competitive Indices of Maize and Soybean Crops Through Intercropping Pattern with Straw Mulching. *Indian Journal Of Agricultural Research*, *58*(5), 800–805. https://doi.org/10.18805/IJARe.A-6244

Sakoda, K., Watanabe, T., Sukemura, S., Kobayashi, S., Nagasaki, Y., Tanaka, Y., & Shiraiwa, T. (2019). Genetic Diversity in Stomatal Density among Soybeans Elucidated Using High-throughput Technique Based on an Algorithm for Object Detection. *Scientific Reports*, *9*(1), 1–9. https://doi.org/10.1038/s41598-019-44127-0

Salgado, G. C., Ambrosano, E. J., Rossi, F., Otsuk, I. P., Ambrosano, G. M. B., Santana, C. A., Muraoka, T., & Trivelin, P. C. O. (2021). Biological n fixation and n transfer in an intercropping system between legumes and organic cherry tomatoes in succession to green corn. *Agriculture (Switzerland)*, *11*(8). https://doi.org/10.3390/agriculture11080690

Salinas-Roco, S., Morales-González, A., Espinoza, S., Pérez-Díaz, R., Carrasco, B., del Pozo, A., & Cabeza, R. A. (2024). N2 Fixation, N Transfer, and Land Equivalent Ratio (LER) in Grain Legume–Wheat Intercropping: Impact of N Supply and Plant Density. *Plants*, *13*(7). https://doi.org/10.3390/plants13070991

Salvagiotti, F., Cassman, K. G., Specht, J. E., Walters, D. T., Weiss, A., & Dobermann, A. (2008). Nitrogen uptake, fixation and response to fertilizer N in soybeans: A review. *Field Crops Research*, *108*(1), 1–13. https://doi.org/10.1016/j.fcr.2008.03.001

Sánchez-Navarro, V., Marcos-Pérez, M., Contreras, J., & Zornoza, R. (2024). Biological nitrogen fixation and intra- and interspecific competition in two vegetable/legume intercropping systems and their relationship to crop yield. *Scientia Horticulturae*, *337*(113502). https://doi.org/10.1016/j.scienta.2024.113502

Sapalina, F., Ginting, E. N., & Hidayat, F. (2022). Bakteri penambat nitrogen sebagai agen biofertilizer. *Warta Pusat Penelitian Kelapa Sawit*, *27*(1), 41–50.

Selosse, M. A., Richard, F., He, X., & Simard, S. W. (2006). Mycorrhizal networks: des liaisons dangereuses? *Trends in Ecology and Evolution*, *21*(11), 621–628. https://doi.org/10.1016/j.tree.2006.07.003

Setiawan, A. N., Isnawan, B. H., & Aini, L. N. (2015). *Sistem Pengelolaan Lahan Pasir Pantai Untuk Pengembangan Pertanian*.

Setiawati, W., Muharam, A., Susanto, A., Boes, E., & Hudayya, A. (2019). PenerapanTeknologi Input Luar Rendah Pada Budidaya Cabai Merah untuk Mengurangi Penggunaan Pupuk dan Pestisida Sintetik (Implementation of Low External Input Technology for Chili Pepper Cultivation to Reduce Fertilizer and Synthetic Pesticide). *Jurnal Hortikultura*, *28*(1), 113. https://doi.org/10.21082/jhort.v28n1.2018.p113-122

Sevirasari, N., Sulistyaningsih, E., Kurniasih, B., Suryanti, S., Wibowo, A., & Joko, T. (2022). Effects of relay intercropping model and application of biological agents on the growth and yield of hot pepper. *Ilmu Pertanian (Agricultural Science)*, *7*(1), 35. https://doi.org/10.22146/ipas.69078

Shah, A., Nazari, M., Antar, M., Msimbira, L. A., Naamala, J., Lyu, D., Rabileh, M., Zajonc, J., & Smith, D. L. (2021). PGPR in Agriculture: A Sustainable Approach to Increasing Climate Change Resilience. *Frontiers in Sustainable Food Systems*, *5*, 1–22. https://doi.org/10.3389/fsufs.2021.667546

Shen, X., Liu, Y., Li, X., & Li, L. (2024). Effect of intercropping with legumes at different rates on the yield and soil physicochemical properties of Cyperus esculentus L. in arid land.

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Frontiers in Plant Science, *15*, 1–12. https://doi.org/10.3389/fpls.2024.1351843

Shine, M. B., Gao, Q., Chowda-Reddy, R. V., Singh, A. K., Kachroo, P., & Kachroo, A. (2019). Glycerol-3-phosphate mediates rhizobia-induced systemic signaling in soybean. *Nature Communications*, *10*(1), 5303. https://doi.org/10.1038/s41467-019-13318-8

Sirait, M. H. A., & Karyawati, A. S. (2019). Pengaruh Naungan pada Pertumbuhan dan Hasil Beberapa Varietas Kedelai (Glycine max (L.) Merr). *Jurnal Produksi Tanaman*, *7*(7), 1304–1313. http://protan.studentjournal.ub.ac.id/index.php/protan/article/view/1179

Sitadz, S. A., & Kabirun, S. (2007). Pengembangan lahan marginal pesisir pantai dengan bioteknologi masukan rendah. *Ilmu Tanah Dan Lingkungan*, *7*(2), 83–92.

Somantri, R. U., Syahri, S., & Thamrin, T. (2019). Keragaan Agronomis dan Kelayakan Usahatani Kedelai yang Dibudidayakan Secara Monokultur dan Polikultur di Sumatera Selatan. *Jurnal Lahan Suboptimal : Journal of Suboptimal Lands*, *8*(2), 159–172. https://doi.org/10.33230/jlso.8.2.2019.426

Song, C., Wang, Q., Zhang, X., Sarpong, C. K., Wang, W., Yong, T., Wang, X., Wang, Y., & Yang, W. (2020). Crop Productivity and Nutrients Recovery in Maize–Soybean Additive Relay Intercropping Systems Under Subtropical Regions in Southwest China. *International Journal of Plant Production*, *14*(2), 373–387. https://doi.org/10.1007/s42106-020-00090-9

Soumare, A., Diedhiou, A. G., Thuita, M., Hafidi, M., Ouhdouch, Y., Gopalakrishnan, S., & Kouisni, L. (2020). Exploiting Biological Nitrogen Fixation: A Route Towards a Sustainable Agriculture. *Plants 2020, Vol. 9, Page 1011*, *9*(8), 1011. https://doi.org/10.3390/PLANTS9081011

Souza, J. a., Fratoni, M. M. J., Moraes, L. A. C., & Moreira, A. (2018). Boron and Amino Acid Foliar Application on Wheat-Soybean Intercropping in a Non-Tillage System. *Communications in Soil Science and Plant Analysis*, *49*(13), 1638–1649. https://doi.org/10.1080/00103624.2018.1474902

Su, B., Liu, X., Cui, L., Xiang, B., & Yang, W. (2018). Suppression of Weeds and Increases in Food Production in Higher Crop Diversity Planting Arrangements: A Case Study of Relay Intercropping. *Crop Science*, *58*(4), 1729–1739. https://doi.org/10.2135/cropsci2017.11.0670 LK

Su, B. Y., Song, Y. X., Song, C., Cui, L., Yong, T. W., & Yang, W. Y. (2014). Growth and photosynthetic responses of soybean seedlings to maize shading in relay intercropping system in Southwest China. *Photosynthetica*, *52*(3), 332–340. https://doi.org/10.1007/s11099-014-0036-7

Su, Y., Yang, H., Wu, Y., Gong, W., Gul, H., Yan, Y., & Yang, W. (2023). Photosynthetic acclimation of shade-grown soybean seedlings to a high-light environment. *Plants*, *12*, 2324. https://doi.org/10.3390/plants12122324

Subagiono, S., Syarif, A., Syarif, Z., & Satria, B. (2019). Tumpangsari Berbasis Legum : a Review. *Jurnal Sains Agro*, *4*(2), 1–7. https://ojs.umb-bungo.ac.id/index.php/saingro/article/view/282/344

Subrata, B. A. G., Yudono, P., & Waluyo, S. (2016). Effect of Plant Density and Sowing Time on Growth and Yield of Mung Bean (VignaRadiata (L.) Wilczek) in Upland Rice-Mung Bean Intercropping on Land Sand Beach Samas Indonesia. *International Journal of Science and Research (IJSR)*, *5*(8), 914–917. https://doi.org/10.21275/v5i8.art2016986

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
Rohimah Handayani Sri Lestari, Dr. Ir. Endang Sulistyaningsih, M.Sc; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Pı
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Sudiono dan Purnomo. (2009). Hubungan Antara Populasi Kutu Kebul. *J. HPT Tropika*, *9*(2), 115–120.

Sukri, M. Z., Sari, V. K., & Firgiyanto, R. (2018). Improving Soil Fertilizer Through Application of Organic Fertilizer Humid Acid and Mikoriza in Supporting Growth and Production of Chilli Plants in Sand Land. *IOP Conference Series: Earth and Environmental Science*, *207*(1). https://doi.org/10.1088/1755-1315/207/1/012056

Sumarno, & Manshuri, A. G. (2013). Persyaratan tumbah dan wilayah produksi kedelai di Indonesia [Requirements for soybean growth and production areas in Indonesia]. In Sumarno, Suyamto, A. Widjono, Hermanto, & H. Kasim (Eds.), *Kedelai :Teknik produksi dan pengembangan [Soybeans: Production techniques and development]* (pp. 74–103). Puslitbangtan.

Sun, B., Wang, Y., Yang, Q., Gao, H., Niu, H., Li, Y., Ma, Q., Huan, Q., Qian, W., & Ren, B. (2023). A high-resolution transcriptomic atlas depicting nitrogen fixation and nodule development in soybean. *Journal of Integrative Plant Biology*, *65*(6), 1536–1552. https://doi.org/10.1111/jipb.13495

Sun, X., Wang, P., & Mi, G. (2025). *Genotypic Differences in Maize Root Morphology in Response to Low-Nitrogen Stress*.

Sun, Y., Zang, H., Splettstößer, T., Kumar, A., Xu, X., Kuzyakov, Y., & Pausch, J. (2021). Plant intraspecific competition and growth stage alter carbon and nitrogen mineralization in the rhizosphere. *Plant Cell and Environment*, *44*(4), 1231–1242. https://doi.org/10.1111/pce.13945

Sundari, T., & Mutmaidah, D. S. (2018). Kesesuaian Galur-Galur Harapan Kedelai untuk Tumpangsari Jagung + Kedelai. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *46*(1), 40. https://doi.org/10.24831/jai.v46i1.14880

Suriyagoda, L. D. B., Ryan, M. H., Renton, M., & Lambers, H. (2014). Plant Responses to Limited Moisture and Phosphorus Availability: A Meta-Analysis. *Advances in Agronomy*, *124*, 143–200. https://doi.org/10.1016/B978-0-12-800138-7.00004-8

Sutardi, & Astri, C. (2017). Sistem Usahatani Cabai Merah Pada Lahan Pasir Di Yogyakarta. *Pengkajian Dan Pengembangan Teknologi Pertanian*, *20*(2), 125–140.

Sutrisno, S., & Wijanarko, A. (2020). Perbedaan lokasi dan waktu tanam terhadap pertumbuhan dan hasil kedelai di lahan sawah Nusa Tenggara Barat [Effect of planting time and location on soybean growth and yield in lowland rice fields of West Nusa Tenggara]. *Agritech*, *21*(2), 82–91. https://doi.org/10.30595/agritech.v21i2.5579

Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant Physiology and Development* (6th ed.). Sinauer Associates Inc.

Tang, Q. xiang, Tewolde, H., Liu, H. bin, Ren, T. zhi, Jiang, P. an, Zhai, L. mei, Lei, B. kun, Lin, T., & Liu, E. ke. (2018). Nitrogen Uptake and Transfer in Broad Bean and Garlic Strip Intercropping Systems. *Journal of Integrative Agriculture*, *17*(1), 220–230. https://doi.org/10.1016/S2095-3119(17)61772-6

Tanveer, M., Anjum, S. A., Hussain, S., Cerdà, A., & Ashraf, U. (2017). Relay cropping as a sustainable approach: problems and opportunities for sustainable crop production. *Environmental Science and Pollution Research*, *24*(8), 6973–6988. https://doi.org/10.1007/s11356-017-8371-4

Taufiq, A., & Sundari, T. (2012). Respon Tanaman Kedelai Terhadap Lingkungan Tumbuh. *Buletin Palawija*, *23*, 13–26.

Tcherkez, G., & Limami, A. M. (2019). Net photosynthetic CO2 assimilation: more than just

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

CO2 and O2 reduction cycles. *New Phytologist*, *223*(2), 520–529. https://doi.org/10.1111/nph.15828

Te, X., Din, A. M. U., Cui, K., Raza, M. A., Fraz Ali, M., & Xiao, J. (2023). Inter-specific root interactions and water use efficiency of maize/soybean relay strip intercropping. *Field Crops Research*, *291*, 108793. https://doi.org/10.1016/j.fcr.2022.108793

Telkar, S. G., Singh, A. K., & Dey, J. K. (2017). Effect of Population Proportion of Component Crops on Groth, Yield and Nutrient Uptake of Component Crops in Maize+Soybean Intercropping. *International Journal of Bio-Resource and Stress Management*, *8*(6), 779–783. https://doi.org/10.23910/IJBSM/2017.8.6.3C0363

Teshome, S. (2019). A Review on Strategy of Developing Intercropping Practices. *International Journal of Current Research and Academic Review*, *7*(1), 61–67. https://doi.org/10.20546/ijcrar.2019.701.007

Thenveettil, N., Bheemanahalli, R., Reddy, K. N., Gao, W., & Reddy, K. R. (2024). Temperature and elevated CO2 alter soybean seed yield and quality, exhibiting transgenerational effects on seedling emergence and vigor. *Frontiers in Plant Science*, *15*(July), 1–18. https://doi.org/10.3389/fpls.2024.1427086

Thilakarathna, M. S., McElroy, M. S., Chapagain, T., Papadopoulos, Y. A., & Raizada, M. N. (2016). Belowground nitrogen transfer from legumes to non-legumes under managed herbaceous cropping systems. A review. *Agronomy for Sustainable Development*, *36*(4). https://doi.org/10.1007/s13593-016-0396-4

Ton, A. (2021). Advantages of Grain Legume-Cereal Intercropping in Sustainable Agriculture. *Turkish Journal of Agriculture - Food Science and Technology*, *9*(8), 1560–1566. https://doi.org/10.24925/turjaf.v9i8.1560-1566.4481

Tsialtas, I. T., Baxevanos, D., Vlachostergios, D. N., Dordas, C., & Lithourgidis, A. (2018). Cultivar complementarity for symbiotic nitrogen fixation and water use efficiency in pea-oat intercrops and its effect on forage yield and quality. *Field Crops Research*, *226*, 28–37. https://doi.org/10.1016/j.fcr.2018.07.005

Van Der Heijden, M. G. A., & Horton, T. R. (2009). Socialism in soil? the importance of mycorrhizal fungal networks for facilitation in natural ecosystems. *Journal of Ecology*, *97*(6), 1139–1150. https://doi.org/10.1111/j.1365-2745.2009.01570.x

Van Rhijn, P., & Vanderleyden, J. (1995). The Rhizobium-plant symbiosis. *Microbiological Reviews*, *59*(1), 124–142. https://doi.org/10.1128/mmbr.59.1.124-142.1995

Vandenbussche, F., Pierik, R., Millenaar, F. F., Voesenek, L. A. C. J., & Van Der Straeten, D. (2005). Reaching out of the shade. *Current Opinion in Plant Biology*, *8*(5), 462–468. https://doi.org/10.1016/j.pbi.2005.07.007

von Caemmerer, S., & Farquhar, G. D. (1981). Some relationships between the biochemistry of photosynthesis and the gas exchange of leaves. *Planta*, *153*(4), 376–387. https://doi.org/10.1007/BF00384257

Vorobey, N., Kukol, K., Pukhtaievych, P., & Kots, T. (2022). Symbiotic and physiological indicators of soybean inoculated of Bradyrhizobium japonicum single-strain in 7 days before sowing. *Acta Agriculturae Slovenica*, *118*(2), 1–11. https://doi.org/10.14720/aas.2022.118.2.1867

Wang, Q., Li, S., Li, J., & Huang, D. (2024). The Utilization and Roles of Nitrogen in Plants. *Forests*, *15*(7). https://doi.org/10.3390/f15071191

Wang, Q., Sun, Z., Bai, W., Zhang, D., Zhang, Yu., Wang, R., Van Der Werf, W., Evers, Jochem, B., Stomph, T.-J., Guo, J., & Zhang, L. (2021). Light interception and use

UNIVERSITAS GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
Rohimah Handayani Sri Lestari, Dr. Ir. Endang Sulistyaningsih, M.Sc; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Pı
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

efficiency differ with maize plant density in maize-peanut intercropping. *Frontiers of Agricultural Science and Engineering*, *8*(3), 432–446. https://doi.org/10.15302/J-FASE-2021403

Wang, T. (2024). <i>Bacillus</I> Suppresses Nitrogen Efficiency of Soybean–rhizobium Symbiosis Through Regulation of Nitrogen-related Transcriptional and Microbial Patterns. *Plant Cell & Environment*, *47*(11), 4305–4322. https://doi.org/10.1111/pce.15023

Wang, X., Li, X., Zhou, Q., Song, S., & Dong, S. (2023). Comparison and Evaluation of Low-Temperature Tolerance of Different Soybean Cultivars during the Early-Growth Stage. In *Agronomy* (Vol. 13, Issue 7, p. 1716). https://doi.org/10.3390/agronomy13071716 LK - https://doi.org/10.3390/agronomy13071716

Wang, Y., Qin, Y., Chai, Q., Feng, F., Zhao, C., & Yu, A. (2018). Interspecies interactions in relation to root distribution across the rooting profile in wheat-maize intercropping under different plant densities. *Frontiers in Plant Science*, *9*(April), 1–17. https://doi.org/10.3389/fpls.2018.00483

Wen, B. xiao, Hussain, S., Yang, J. yue, Wang, S., Zhang, Y., Qin, S. si, Xu, M., Yang, W. yu, & Liu, W. guo. (2020). Rejuvenating soybean (Glycine max L.) growth and development through slight shading stress. *Journal of Integrative Agriculture*, *19*(10), 2439–2450. https://doi.org/10.1016/S2095-3119(20)63159-8

Widodo, A. S. (2015). Pendapatan dan Produksi Potensial Usahatani Konservasi Lahan Pantai di Kabupaten Bantul. *AGRARIS: Journal of Agribusiness and Rural Development Research*, *1*(1), 1–5. https://doi.org/10.18196/agr.111

Wu, Y., Gong, W., Yang, F., Wang, X., Yong, T., Liu, J., Pu, T., Yan, Y., & Yang, W. (2022). Dynamic of recovery growth of intercropped soybean after maize harvest in maize–soybean relay strip intercropping system. *Food and Energy Security*, *11*(1), 1–14. https://doi.org/10.1002/fes3.350

Wysokinski, A., Wysokińska, A., Noulas, C., & Wysokińska, A. (2024). Optimal Nitrogen Fertilizer Rates for Soybean Cultivation. *Agronomy*, *14*(7), 1–12. https://doi.org/10.3390/agronomy14071375

Xia, H. Y., Zhao, J. H., Sun, J. H., Bao, X. G., Christie, P., Zhang, F. S., & Li, L. (2013). Dynamics of root length and distribution and shoot biomass of maize as affected by intercropping with different companion crops and phosphorus application rates. *Field Crops Research*, *150*, 52–62. https://doi.org/10.1016/j.fcr.2013.05.027

Xiao, J., Yin, X., Ren, J., Zhang, M., Tang, L., & Zheng, Y. (2018). Complementation drives higher growth rate and yield of wheat and saves nitrogen fertilizer in wheat and faba bean intercropping. *Field Crops Research*, *221*, 119–129. https://doi.org/10.1016/j.fcr.2017.12.009

Xiao, Y., Yang, D., Zhang, S.-B., Mo, Y.-X., Dong, Y.-Y., Wang, K.-F., He, L.-Y., Dong, B., Dossa, G. G. O., & Zhang, J.-L. (2024). Nitrogen-fixing and non-nitrogen-fixing legume plants differ in leaf nutrient concentrations and relationships between photosynthetic and hydraulic traits. *Tree Physiology*, *44*(5), tpae048. https://doi.org/10.1093/treephys/tpae048

Yang, F., Feng, L., Liu, Q., Wu, X., Fan, Y., Raza, M. A., Cheng, Y., Chen, J., Wang, X., Yong, T., Liu, W., Liu, J., Du, J., Shu, K., & Yang, W. (2018). Effect of interactions between light intensity and red-to- far-red ratio on the photosynthesis of soybean leaves under shade condition. *Environmental and Experimental Botany*, *150*(February), 79–87. https://doi.org/10.1016/j.envexpbot.2018.03.008

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Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
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Yang, F., Liao, D., Wu, X., Gao, R., Fan, Y., Raza, M. A., Wang, X., Yong, T., Liu, W., Liu, J., Du, J., Shu, K., & Yang, W. (2017). Effect of aboveground and belowground interactions on the intercrop yields in maize-soybean relay intercropping systems. *Field Crops Research*, *203*, 16–23. https://doi.org/10.1016/j.fcr.2016.12.007

Yin, W., Chai, Q., Zhao, C., Yu, A., Fan, Z., Hu, F., Fan, H., Guo, Y., & Coulter, J. A. (2020). Water utilization in intercropping: A review. *Agricultural Water Management*, *241*, 106335. https://doi.org/10.1016/j.agwat.2020.106335

Yong, T. wen, Chen, P., Dong, Q., Du, Q., Yang, F., Wang, X. chun, Liu, W. guo, & Yang, W. yu. (2018). Optimized nitrogen application methods to improve nitrogen use efficiency and nodule nitrogen fixation in a maize-soybean relay intercropping system. *Journal of Integrative Agriculture*, *17*(3), 664–676. https://doi.org/10.1016/S2095-3119(17)61836-7

Yu, Y., Stomph, T. J., Makowski, D., & van der Werf, W. (2015). Temporal niche differentiation increases the land equivalent ratio of annual intercrops: A meta-analysis. *Field Crops Research*, *184*, 133–144. https://doi.org/10.1016/j.fcr.2015.09.010

Zhang, F., & Li, L. (2003). Using competitive and facilitative interactions in intercropping systems enhances crop productivity and nutrient-use efficiency. *Plant and Soil*, *248*(1–2), 305–312. https://doi.org/10.1023/A:1022352229863

Zhang, G., Hou, Y., Zhang, H., Fan, H., Wen, X., Han, J., & Liao, Y. (2022). Optimizing planting pattern and nitrogen application rate improves grain yield and water use efficiency for rain-fed spring maize by promoting root growth and reducing redundant root growth. *Soil and Tillage Research*, *220*, 105385. https://doi.org/10.1016/j.still.2022.105385

Zhang, H., Zeng, F., Zou, Z., Zhang, Z., & Li, Y. (2017). Nitrogen uptake and transfer in a soybean/maize intercropping system in the karst region of southwest China. In *Ecology and Evolution* (Vol. 7, Issue 20, pp. 8419–8426). https://doi.org/10.1002/ece3.3295 LK - https://doi.org/10.1002/ece3.3295

Zhang, M. cong, Sun, W. xiang, Liu, Y. ying, Luo, S. guo, Zhao, J., Wu, Q., Wu, Z. yu, & Jiang, Y. (2014). Timing of N Application Affects Net Primary Production of Soybean with Different Planting Densities. *Journal of Integrative Agriculture*, *13*(12), 2778–2787. https://doi.org/10.1016/S2095-3119(13)60535-3

Zhang, R., Wang, C., Teng, W., Wang, J., Lyu, X., Dong, S., Kang, S., Gong, Z., & Ma, C. (2020). Accumulation and distribution of fertilizer nitrogen and nodule-fixed nitrogen in soybeans with dual root systems. *Agronomy*, *10*(3). https://doi.org/10.3390/agronomy10030397

Zhang, T., Tang, H., Peng, P., Ge, S., Liu, Y., Feng, Y., & Wang, J. (2023). Sugarcane/soybean intercropping with reduced nitrogen addition promotes photosynthesized carbon sequestration in the soil. *Frontiers in Plant Science*, *14*(December), 1–14. https://doi.org/10.3389/fpls.2023.1282083

Zhang, W. F., Dou, Z. X., He, P., Ju, X. T., Powlson, D., Chadwick, D., Norse, D., Lu, Y. L., Zhang, Y., Wu, L., Chen, X. P., Cassman, K. G., & Zhang, F. S. (2013). New technologies reduce greenhouse gas emissions from nitrogenous fertilizer in China. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(21), 8375–8380. https://doi.org/10.1073/pnas.1210447110

Zhang, Y., Sun, Z., Su, Z., Du, G., Bai, W., Wang, Q., Wang, R., Nie, J., Sun, T., Feng, C., Zhang, Z., Yang, N., Zhang, X., Evers, J. B., van der Werf, W., & Zhang, L. (2022).

UNIVERSITAS
GADJAH MADA
Pertumbuhan, Hasil Dan Fungsi Komplementer Kedelai Pada Sistem Tumpang Sisip Cabai Di Lahan Pasir Pantai
Rohimah Handayani Sri Lestari, Dr. Ir. Endang Sulistyaningsih, M.Sc; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Pı
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Root plasticity and interspecific complementarity improve yields and water use efficiency of maize/soybean intercropping in a water-limited condition. *Field Crops Research*, *282*, 108523. https://doi.org/10.1016/j.fcr.2022.108523

Zhang, Z., Yu, Z., Zhang, Y., & Shi, Y. (2022). Impacts of fertilization optimization on soil nitrogen cycling and wheat nitrogen utilization under water-saving irrigation. *Frontiers in Plant Science*, *13*, 1–13. https://doi.org/10.3389/fpls.2022.878424

Zhao, Y., Tian, Y., Li, X., Song, M., Fang, X., Jiang, Y., & Xu, X. (2022). Nitrogen fixation and transfer between legumes and cereals under various cropping regimes. *Rhizosphere*, *22*(May), 100546. https://doi.org/10.1016/j.rhisph.2022.100546

Zhao, Z., Li, Z., Li, Y., Yu, L., Gu, X., & Cai, H. (2024). Supplementary irrigation and reduced nitrogen application improve the productivity, water and nitrogen use efficiency of maize-soybean intercropping system in the semi-humid drought-prone region of China. *Agricultural Water Management*, *305*, 109126. https://doi.org/10.1016/j.agwat.2024.109126

Zheng, B. chuan, Zhou, Y., Chen, P., Zhang, X. na, Du, Q., Yang, H., Wang, X. chun, Yang, F., Xiao, T., Li, L., Yang, W. yu, & Yong, T. wen. (2022). Maize–legume intercropping promote N uptake through changing the root spatial distribution, legume nodulation capacity, and soil N availability. *Journal of Integrative Agriculture*, *21*(6), 1755–1771. https://doi.org/10.1016/S2095-3119(21)63730-9

Zhou, J., Beche, E., Vieira, C. C., Yungbluth, D., Zhou, J., Scaboo, A., & Chen, P. (2022). Improve Soybean Variety Selection Accuracy Using UAV-Based High-Throughput Phenotyping Technology. *Frontiers in Plant Science*, *12*. https://doi.org/10.3389/fpls.2021.768742