

Rosnina AG

Ekologi Tanaman



EKOLOGI TANAMAN

ROSNINA AG



Penerbit KBM Indonesia

Adalah penerbit dengan misi memudahkan proses penerbitan buku-buku penulis di tanah air indonesia, serta menjadi media *sharing* proses penerbitan buku

EKOLOGI TANAMAN

Copyright @2025 by Rosnina AG

All rights reserved

KARYA BAKTI MAKMUR (KBM) INDONESIA

Anggota IKAPI (Ikatan Penerbit Indonesia)

NO. IKAPI 279/JTI/2021

Depok, Sleman-Jogjakarta (Kantor)

081357517526 (Tlpn/WA)

Penulis

Rosnina AG

Desain Sampul

Aswan Kreatif

Tata Letak

Ara Caraka

Editor Naskah

Dr. Nasruddin, S.P, M.P

15,5 x 23 cm, xii + 428 halaman

Cetakan ke-1, November 2025

ISBN 978-634-202-943-5

Isi buku diluar tanggungjawab penerbit

Hak cipta merek KBM Indonesia sudah terdaftar di

DJKI-Kemenkumham dan isi buku dilindungi undang-undang

Dilarang keras menerjemahkan, memfotokopi, atau

Memperbanyak sebagian atau seluruh isi buku ini

Tanpa seizin penerbit karena beresiko sengketa hukum

Website

<https://penerbitkbm.com>

www.penerbitbukumurah.com

Instagram

@penerbit.kbmindonesia

@penerbitbukujogja

Email

naskah@penerbitkbm.com

Distributor

<https://penerbitkbm.com/toko-buku/>

Youtube

Penerbit KBM Sastrabook

Sanksi Pelanggaran Pasal 113

Undang-Undang No. 28 Tahun 2014 Tentang Hak Cipta

- (i) Setiap Orang yang dengan tanpa hak melakukan pelanggaran hak ekonomi sebagaimana dimaksud dalam Pasal 9 ayat (1) huruf i untuk Penggunaan Secara Komersial dipidana dengan pidana penjara paling lama 1 (satu) tahun dan/atau pidana denda paling banyak Rp 100.000.000 (seratus juta rupiah).
- (ii) Setiap Orang yang dengan tanpa hak dan/atau tanpa izin Pencipta atau pemegang Hak Cipta melakukan pelanggaran hak ekonomi Pencipta sebagaimana dimaksud dalam Pasal 9 ayat (1) huruf c, huruf d, huruf f, dan/atau huruf h untuk Penggunaan Secara Komersial dipidana dengan pidana penjara paling lama 3 (tiga) tahun dan/atau pidana denda paling banyak Rp 500.000.000,00 (lima ratus juta rupiah).
- (iii) Setiap Orang yang dengan tanpa hak dan/atau tanpa izin Pencipta atau pemegang Hak Cipta melakukan pelanggaran hak ekonomi Pencipta sebagaimana dimaksud dalam Pasal 9 ayat (1) huruf a, huruf b, huruf e, dan/atau huruf g untuk Penggunaan Secara Komersial dipidana dengan pidana penjara paling lama 4 (empat) tahun dan/atau pidana denda paling banyak Rp 1.000.000.000,00 (satu miliar rupiah).
- (iv) Setiap Orang yang memenuhi unsur sebagaimana dimaksud pada ayat (3) yang dilakukan dalam bentuk pembajakan, dipidana dengan pidana penjara paling lama 10 (sepuluh) tahun dan/atau pidana denda paling banyak Rp 4.000.000.000,00 (empat miliar).

KATA PENGANTAR

Puji syukur penulis panjatkan ke hadirat Tuhan Yang Maha Esa atas limpahan rahmat dan karunia-Nya, sehingga penulisan buku ajar Ekologi Tanaman ini dapat diselesaikan dengan baik. Buku ini disusun sebagai bentuk kontribusi dalam pengembangan sumber belajar yang mendukung pemahaman mahasiswa terhadap hubungan timbal balik antara tanaman dan lingkungan hidupnya, dalam konteks dinamika ekosistem, adaptasi fisiologis, dan perubahan lingkungan global.

Penulis menyampaikan apresiasi yang setinggi-tingginya kepada Rektor Universitas Malikussaleh, Dekan Fakultas Pertanian, Ketua Jurusan Budidaya Pertanian, serta Ketua Program Studi Agroekoteknologi atas kepercayaan dan dukungan yang telah diberikan. Ucapan terima kasih juga disampaikan kepada keluarga tercinta serta rekan-rekan dosen di Program Studi Agroekoteknologi atas kolaborasi dan semangat akademik yang senantiasa menjadi inspirasi dalam penyusunan karya ini.

Buku ajar ini ditujukan sebagai referensi utama bagi mahasiswa dalam memahami prinsip-prinsip dasar ekologi tanaman, mencakup aspek struktur komunitas tumbuhan, interaksi biotik-abiotik, strategi adaptasi, serta implikasinya terhadap keberlanjutan agroekosistem. Diharapkan buku ini dapat memperkuat kapasitas analitis mahasiswa dalam merespons tantangan ekologis masa kini, seperti degradasi lahan, perubahan iklim, dan penurunan keanekaragaman hayati.

Akhir kata, penulis menyampaikan terima kasih kepada semua pihak yang telah memberikan kontribusi, baik secara langsung maupun tidak langsung, dalam proses penulisan dan penyempurnaan buku ajar ini. Semoga buku ini dapat bermanfaat

bagi pengembangan ilmu pengetahuan dan praktik pertanian yang selaras dengan prinsip-prinsip ekologi.

Aceh Utara, November 2025

Penulis,

Rosnina AG

DAFTAR ISI

KATA PENGANTAR	i
DAFTAR ISI.....	iii
DAFTAR GAMBAR	ix
DAFTAR TABEL	xi
BAB 01 PENGERTIAN EKOLOGI DAN HUBUNGANNYA DENGAN ILMU-ILMU LAINNYA.....	1
1.1 Pengertian Dan Ruang Lingkup Kajian Ekologi Tanaman ..	3
1.2 Hubungan Ekologi Tanaman Dengan Ilmu-Ilmu Eksakta Dan Sosial	12
1.3 Pengertian Ekologi Sebagai Ilmu	17
1.4 Pembagian Ekologi.....	22
1.5 Model-Model Ekologi.....	25
BAB 02 PRINSIP DAN KONSEP EKOSISTEM	33
2.1 Pengertian Ekosistem.....	34
2.2 Konsep Ekosistem	37
2.3 Komponen Ekosistem.....	40
2.4 Pengendalian Secara Biologi Dan Dari Lingkungan Kimia	44
2.5 Produksi Dan Dekomposisi Di Alam.....	46
2.6 Produktivitas Beberapa Ekosistem Tropika	49
2.7 Homeostasis Ekosistem.....	56
BAB 03 EKOSISTEM PERTANIAN	61
3.1 Konservasi Keanekaragaman Hayati	63
3.2 Kekayaan Sumber Hayati Baru	66
3.3 Erosi Genetik Akibat Pertanian Modern	69
3.4 Dampak Tumbuhan Transgenik	71
3.5 Lingkungan Makanan Memburuk	74
3.6 Punahnya Puluhan Ribuan Makhluk Hidup	75
3.7 Bioteknologi Sebagai Tantangan Ekosistem Masa Depan..	78

3.8	Krisis Dan Erosi Sumber Keanekaragaman Hayati.....	80
3.9	Rantai Makanan, Jaring Pangan, Dan Tingkat Trofik.....	82
3.10	Metabolisme Dan Ukuran Individu-Individu.....	84
3.11	Struktur Trofik Dan Piramida Ekologi.....	87
3.12	Energetika Ekosistem Pertanian.....	89
BAB 04 CEKAMAN LINGKUNGAN		95
4.1	Arti Lingkungan Hidup.....	97
4.2	Mutu Lingkungan Hidup	98
4.3	Manfaat Dan Resiko Lingkungan.....	99
4.4	Efek Rumah Kaca.....	101
4.5	Fotosintesis.....	103
4.6	Perombakan Nitrogen.....	105
4.7	Pengendalian Populasi	109
4.8	Penyerbukan	111
4.9	Kemampuan Memperbaharui Diri.....	115
4.10	Fungsi Hidrologi.....	118
BAB 05 KERUSAKAN LINGKUNGAN		123
5.1	Kerusakan Lingkungan Kota.....	124
5.2	Kerusakan Lingkungan Pedesaan.....	127
5.3	Penanggulangan Kerusakan Lingkungan: Sawah, Pekarangan, Sistem Talun – Kebun, Perkebunan Rakyat, Perikanan....	128
5.4	Prioritas Penanggulangan	130
5.5	Dampak Kerusakan Lingkungan Terhadap Struktur Komunitas.....	132
5.6	Pengaruh Kerusakan Lingkungan Terhadap Keanekaragaman Komunitas	135
5.7	Ekotone Sebagai Indikator Perubahan Ekologis.....	136
5.8	Pembelajaran Paleoekologi Untuk Restorasi Ekosistem...	137
BAB 06 VEGETASI DI DAERAH TROPIS		141
6.1	Hutan Hujan Tropis	142
6.2	Hutan Gugur Tropis	144
6.3	Hutan Montana Tropis	146
6.4	Savana Dan Gurun Tropis	148
6.5	Vegetasi Rawa Tropis.....	149

6.6	Hubungan Tanaman Dan Air	151
6.7	Hubungan Tanaman Dan Cahaya	153
6.8	Hubungan Tanaman Dan Udara	155
BAB 07 TANAMAN DAN AIR		161
7.1	Hubungan Antara Tanaman Dan Air	162
7.2	Formasi Tanah	163
7.3	Struktur Tanah	166
7.4	Neraca Air Tanah	168
7.5	Jenis-Jenis Tanah Tropis.....	171
7.6	Bahan Organik Dan Unsur Hara.....	174
7.7	Keasaman Dan Kebasaan Tanah	177
BAB 08 TANAMAN DAN AIR (LANJUTAN).....		183
8.1	Siklus Hidrologi.....	184
8.2	Presipitasi	187
8.3	Kelembaban Dan Keawanan	189
8.4	Kegunaan Uap Air Bagi Tanaman	193
8.5	Tipe Tanaman Berdasarkan Mekanisme Adaptasi Terhadap Air.....	196
8.6	Kekuatan Evapotranspirasi	201
8.7	Transpirasi	203
8.8	Evaporasi	204
8.9	Neraca Air.....	208
8.10	Layu Sementara Dan Layu Permanen	210
8.11	Konstanta Air Dan Tipe Air Tanah.....	213
8.12	Klasifikasi Tanaman Berdasarkan Kebutuhan Air.....	214
8.13	Air Dan Pertumbuhan Tanaman.....	217
BAB 09 TANAMAN DAN CAHAYA		221
9.1	Suhu Tanah.....	222
9.2	Suhu Tanaman	224
9.3	Fotosintesis.....	225
9.4	Fotoperiodisme Dan Termoperiodisme.....	227
9.5	Pengaruh Altitud Terhadap Pertumbuhan Tanaman	229
9.6	Tanaman Heliophyta Dan Sciophyta.....	232

9.7	Adaptasi Terhadap Intensitas Cahaya Tinggi	234
9.8	Fototropisme	236
BAB 10 TANAMAN DAN UDARA.....		241
10.1	Pentingnya Gas Bagi Tumbuhan.....	242
10.2	Daur Oksigen Dan Karbon Dioksida (CO ₂).....	245
10.3	Peran CO ₂ Dalam Fotosintesis.....	246
10.4	Fungsi Dan Struktur Stomata Tumbuhan.....	249
10.5	Produktivitas Primer Dan Kaitannya Dengan Udara.....	250
10.6	Atmosfer Tanah: Komposisi Dan Dinamika Gas	252
10.7	Pengaruh Konsentrasi Oksigen Rendah Terhadap Tumbuhan	256
10.8	Adaptasi Tumbuhan Terhadap Kondisi Oksigen Rendah.....	257
10.9	Perkecambahan Dan Kebutuhan Oksigen.....	259
10.10	Peran Angin Terhadap Pertumbuhan Dan Gas-Gas Tanaman.....	261
BAB 11 INTERAKSI ANTARA TANAMAN DAN LINGKUNGAN BIOTIK DAN ABIOTIK.....		267
11.1	Persaingan Antar Tanaman	268
11.2	Simbiosis	270
11.3	Mikrotopi	272
11.4	Fiksasi Nitrogen.....	275
11.5	Parasitisme	276
11.6	Alelopati, Antibiotik, Dan Fitoaleksin.....	279
BAB 12 TANAMAN DAN MANUSIA		285
12.1	Grazing Dan Browsing.....	286
12.2	Tanaman Bersemak	289
12.3	Mekanisme Ketahanan Tanaman	292
12.4	Aktivitas Perusakan Oleh Hewan.....	295
12.5	Tanaman Karnivora.....	298
12.6	Penyerbukan Oleh Hewan	301
12.7	Penyebaran Buah Dan Biji Oleh Hewan.....	304
12.8	Kebakaran.....	306

12.9 Bercocok Tanam.....	309
12.10 Erosi.....	310
12.11 Pencemaran.....	312
BAB 13 KAJIAN LINGKUNGAN	317
13.1 Karakteristik Tanah	318
13.2 Kecepatan Laju Fiksasi Nitrogen	326
13.3 Air Dalam Siklus Hidrologi.....	328
13.4 Radiasi Dan Temperatur.....	330
13.5 Pengukuran Atmosfer.....	333
13.6 Fauna Dan Spesies Tanaman	338
13.7 Fauna Dan Vegetasi.....	340
BAB 14 AZAS-AZAS DAN KONSEP-KONSEP MENGENAI ENERGI DI DALAM SISTEM-SISTEM EKOLOGI	347
14.1 Azas-Azas Energi Dalam Ekologi.....	348
14.2 Konsep Energi Dalam Sistem Ekologi.....	357
BAB 15 TANAMAN SEBAGAI SUMBER BIOFUEL.....	367
15.1 Klasifikasi Tanaman Berdasarkan Jenis Biofuel.....	368
15.2 Tanaman Penghasil Minyak Untuk Biodiesel	373
15.3 Tanaman Penghasil Gula Dan Pati Untuk Bioetanol.....	377
15.4 Tanaman Energi Generasi Baru	381
15.5 Tanaman Potensial Lain Sebagai Biofuel	384
15.6 Analisis Ekologis Pemanfaatan Tanaman Bioenergi	390
15.7 Strategi Pengembangan Biofuel Berbasis Tumbuhan	393
DAFTAR PUSTAKA	399
PROFIL PENULIS.....	427

DAFTAR PUSTAKA

- Adamec, L., Matušíková, I., & Pavlovič, A. (2021). Recent ecophysiological, biochemical and evolutionary insights into plant carnivory. *Annals of Botany*, 128(3), 241-259. <https://doi.org/10.1093/aob/mcab071>.
- Adler, P. B., Smull, D., Beard, K. H., Choi, R. T., Furniss, T., Kulmatiski, A., ... & Veblen, K. E. (2018). Competition and coexistence in plant communities: intraspecific competition is stronger than interspecific competition. *Ecology letters*, 21(9), 1319-1329. <https://doi.org/10.1111/ele.13098>.
- Alam, M. Z., Haque, M. M., Islam, M. S., Hossain, E., Hasan, S. B., Hasan, S. B., & Hossain, M. S. (2016). Comparative study of integrated pest management and farmers practices on sustainable environment in the rice ecosystem. *International journal of zoology*, 2016(1), 7286040. <https://doi.org/10.1155/2016/7286040>.
- Allen, E. B., & Forman, R. T. (1976). Plant species removals and old-field community structure and stability. *Ecology*, 57(6), 1233-1243. <https://doi.org/10.2307/1935047>.
- Allen, K., Dupuy, J. M., Gei, M. G., Hulshof, C., Medvigy, D., Pizano, C., ... & Powers, J. S. (2017). Will seasonally dry tropical forests be sensitive or resistant to future changes in rainfall regimes?. *Environmental Research Letters*, 12(2), 023001. <https://doi.org/10.1088/1748-9326/aa5968>.
- Altdorff, D., Galagedara, L., & Unc, A. (2017). Impact of projected land conversion on water balance of boreal soils in western Newfoundland. *Journal of Water and Climate*

- Change*, 8(4), 613-626. <https://doi.org/10.2166/WCC.2017.016>.
- Anache, J. A., Wendland, E., Rosalem, L. M., Youlton, C., & Oliveira, P. T. (2019). Hydrological trade-offs due to different land covers and land uses in the Brazilian Cerrado. *Hydrology and Earth System Sciences*, 23(3), 1263-1279. <https://doi.org/10.5194/HESS-23-1263-2019>.
- Anderson, R. G., & French, A. N. (2019). Crop evapotranspiration. *Agronomy*, 9(10), 614. <https://doi.org/10.3390/agronomy9100614>.
- Aggarwal, P. K., Joshi, H. C., Kumar, S., Gupta, N., & Kumar, S. (2007). Fuel ethanol production from Indian agriculture: opportunities and constraints. *Outlook on AGRICULTURE*, 36(3), 167-174. <https://doi.org/10.5367/0000000007781891522>.
- Antenozio, M. L., Caissutti, C., Caporusso, F. M., Marzi, D., & Brunetti, P. (2024). Urban air pollution and plant tolerance: Omics responses to ozone, nitrogen oxides, and particulate matter. *Plants*, 13(15), 2027. <https://doi.org/10.3390/plants13152027>.
- Aros-Mualin, D., & Kessler, M. (2024). Untangling poikilohydry and desiccation tolerance: evolutionary and macroecological drivers in ferns. *Annals of Botany*, 134(7), 1139-1150. <https://doi.org/10.1093/aob/mcae167>.
- Aschehoug, E. T., Brooker, R., Atwater, D. Z., Maron, J. L., & Callaway, R. M. (2016). The mechanisms and consequences of interspecific competition among plants. *Annual Review of Ecology, Evolution, and Systematics*, 47(1), 263-281. <https://doi.org/10.1146/ANNUREV-ECOLSYS-121415-032123>.
- Asnur, P. (2021). Kemampuan Dan Klasifikasi Penggunaan Lahan Untuk Pertanian Di Kabupaten Pariaman,

- Sumatera Barat: Paranita Asnur, Rini Laraswati. *Jurnal Akar*, 3(1), 32-38.
- Ayres, K. W., Button, R. G., & Jong, E. D. (1972). Soil morphology and soil physical properties. I. Soil aeration. *Canadian Journal of Soil Science*, 52(3), 311-321. <https://doi.org/10.4141/CJSS72-043>.
- Balint-Kurti, P., & Pataky, J. (2024). Reconsidering the lessons learned from the 1970 southern corn leaf blight epidemic. *Phytopathology*®, 114(9), 2007-2016. <https://doi.org/10.1094/PHYTO-03-24-0105-PER>.
- Barneche, D. R., Hulatt, C. J., Dossena, M., Padfield, D., Woodward, G., Trimmer, M., & Yvon-Durocher, G. (2021). Warming impairs trophic transfer efficiency in a long-term field experiment. *Nature*, 592(7852), 76-79. <https://doi.org/10.1038/s41586-021-03352-2>.
- Barzman, M., Bàrberi, P., Birch, A. N. E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B., ... & Sattin, M. (2015). Eight principles of integrated pest management. *Agronomy for sustainable development*, 35, 1199-1215. <https://doi.org/10.1007/s13593-015-0327-9>.
- Behie, S. W., & Bidochka, M. J. (2013). Insects as a nitrogen source for plants. *Insects*, 4(3), 413-424. <https://doi.org/10.3390/insects4030413>.
- Bernhardt, J. R., & Leslie, H. M. (2013). Resilience to climate change in coastal marine ecosystems. *Annual review of marine science*, 5(1), 371-392. <https://doi.org/10.1146/annurev-marine-121211-172411>.
- Besnard, G., Dufay, M., & Schatz, B. (2021). Investigating pollination strategies in a changing world. *Botany Letters*, 168(3), 311-315. <https://doi.org/10.1080/23818107.2021.1965018>.
- Bonal, D., Burban, B., Stahl, C., Wagner, F., & Hérault, B. (2016). The response of tropical rainforests to drought—lessons

- from recent research and future prospects. *Annals of forest science*, 73, 27-44. <https://doi.org/10.1007/s13595-015-0522-5>.
- Boyle, T. P., Sebaugh, J., & Robinson-Wilson, E. (1984). A hierarchical approach to the measurement of changes in community structure induced by environmental stress. *Journal of testing and evaluation*, 12(4), 241-245. <https://doi.org/10.1520/JTE10719J>.
- Brown, J. H., Gillooly, J. F., Allen, A. P., Savage, V. M., & West, G. B. (2004). Toward a metabolic theory of ecology. *Ecology*, 85(7), 1771-1789. <https://doi.org/10.1890/03-9000>.
- Bruijnzeel, L. A., & Veneklaas, E. J. (1998). Climatic conditions and tropical montane forest productivity: the fog has not lifted yet. *Ecology*, 79(1), 3-9. [https://doi.org/10.1890/0012-9658\(1998\)079\[0003:CCATMF\]2.0.CO;2](https://doi.org/10.1890/0012-9658(1998)079[0003:CCATMF]2.0.CO;2).
- Brutsaert, W. (1986). Catchment-scale evaporation and the atmospheric boundary layer. *Water Resources Research*, 22(9S), 39S-45S. <https://doi.org/10.1029/WR022I09SP0039S>.
- Burkepile, D. E., & Parker, J. D. (2017). Recent advances in plant-herbivore interactions. *F1000Research*, 6, 119. <https://doi.org/10.12688/f1000research.10313.1>.
- Byrt, C. S., Grof, C. P., & Furbank, R. T. (2011). C4 Plants as biofuel feedstocks: optimising biomass production and feedstock quality from a lignocellulosic perspective free access. *Journal of integrative plant biology*, 53(2), 120-135. <https://doi.org/10.1111/j.1744-7909.2010.01023.x>.
- Cairns Jr, J. (1974). Indicator species vs. the concept of community structure as an index of pollution. *Water Resour. Bull. (United States)*, 10(2). <https://doi.org/10.1111/J.1752-1688.1974.TB00573.X>.

- Carnevale Zampaolo, F., Kassam, A., Friedrich, T., Parr, A., & Uphoff, N. (2023). Compatibility between Conservation Agriculture and the System of Rice Intensification. *Agronomy*, 13(11), 2758. <https://doi.org/10.20944/preprints202309.1689.v1>.
- Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. (2015). Accelerated modern human-induced species losses: Entering the sixth mass extinction. *Science advances*, 1(5), e1400253. <https://doi.org/10.1126/sciadv.1400253>.
- Chambers, J. C., & MacMahon, J. A. (1994). A day in the life of a seed: movements and fates of seeds and their implications for natural and managed systems. *Annual review of ecology and systematics*, 263-292. <https://doi.org/10.1146/ANNUREV.ES.25.110194.001403>.
- Chen, W. H., Lin, B. J., Huang, M. Y., & Chang, J. S. (2015). Thermochemical conversion of microalgal biomass into biofuels: a review. *Bioresource technology*, 184, 314-327. <https://doi.org/10.1016/j.biortech.2014.11.050>.
- Čimo, J., & Šiška, B. (2006). Design and realization of monitoring system for measuring air temperature and humidity, wind direction and speed. *Journal of Environmental Engineering and Landscape Management*, 14(3), 127-134. <https://doi.org/10.3846/16486897.2006.9636889>.
- Cloud Jr, P. E. (1959). Paleocology: retrospect and prospect. *Journal of Paleontology*, 926-962.
- Cocco, D. (2007). Comparative study on energy sustainability of biofuel production chains. *Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy*, 221(5), 637-645. <https://doi.org/10.1243/09576509JPE365>.

- Conrad, M. (1972). Stability of foodwebs and its relation to species diversity. *Journal of Theoretical Biology*, 34(2), 325-335. [https://doi.org/10.1016/0022-5193\(72\)90165-8](https://doi.org/10.1016/0022-5193(72)90165-8).
- Corbineau, F. (2022). Oxygen, a key signalling factor in the control of seed germination and dormancy. *Seed Science Research*, 32(3), 126-136. <https://doi.org/10.1017/S096025852200006X>.
- Corrado, G., & Rao, R. (2017). Towards the genomic basis of local adaptation in landraces. *Diversity*, 9(4), 51. <https://doi.org/10.3390/D9040051>.
- Costa, J. A. V., & De Morais, M. G. (2011). The role of biochemical engineering in the production of biofuels from microalgae. *Bioresource technology*, 102(1), 2-9. <https://doi.org/10.1016/j.biortech.2010.06.014>.
- Craine, J. M., & Dybzinski, R. (2013). Mechanisms of plant competition for nutrients, water and light. *Functional Ecology*, 27(4), 833-840. <https://doi.org/10.1111/1365-2435.12081>.
- Czarna, M., Kolodziejczak, M., & Janska, H. (2016). Mitochondrial proteome studies in seeds during germination. *Proteomes*, 4(2), 19. <https://doi.org/10.3390/proteomes4020019>.
- Dahlgreen, J., & Parr, A. (2024). Exploring the impact of alternate wetting and drying and the system of rice intensification on greenhouse gas emissions: a review of rice cultivation practices. *Agronomy*, 14(2), 378. <https://doi.org/10.3390/agronomy14020378>.
- De Costa, W. A. J. M. (2011). A review of the possible impacts of climate change on forests in the humid tropics. *Journal of the National Science Foundation of Sri Lanka*, 39(4). <https://doi.org/10.4038/JNSFSR.V39I4.3879>.
- De Bartolo, S., Otten, W., Cheng, Q., & Tarquis, A. M. (2011). Preface" Modeling soil system: complexity under your

- feet". *Biogeosciences*, 8(11), 3139-3142.
<https://doi.org/10.5194/BG-8-3139-2011>.
- DeLucia, E. H., Heckathorn, S. A., & Day, T. A. (1992). Effects of soil temperature on growth, biomass allocation and resource acquisition of *Andropogon gerardii* Vitman. *New Phytologist*, 120(4), 543-549. <https://doi.org/10.1111/J.1469-8137.1992.TB01804.X>.
- de Miranda, R. A. C., Milde, L. C. E., Bichara, A. L., & Cornell, S. (1994). Caracterização do ciclo diário dos perfis de temperatura do ar e umidade relativa em uma plantação de cacau. *Pesquisa Agropecuária Brasileira*, 29(3), 345-353.
- Demirbas, A. (2007). Recent developments in biodiesel fuels. *International Journal of Green Energy*, 4(1), 15-26. <https://doi.org/10.1080/15435070601015395>.
- De Ruiter, P. C., Neutel, A. M., & Moore, J. C. (1995). Energetics, patterns of interaction strengths, and stability in real ecosystems. *Science*, 269(5228), 1257-1260. <https://doi.org/10.1126/science.269.5228.1257>.
- Dimitriadou, S., & Nikolakopoulos, K. G. (2021). Evapotranspiration trends and interactions in light of the anthropogenic footprint and the climate crisis: A review. *Hydrology*, 8(4), 163. <https://doi.org/10.3390/hydrology8040163>.
- Dobbert, S., Pape, R., & Löffler, J. (2022). On growth patterns and mechanisms in arctic-alpine shrubs. *Erdkunde*, (H. 3), 199-226. <https://doi.org/10.3112/erdkunde.2022.03.04>.
- Dror, I., Yaron, B., & Berkowitz, B. (2021). The human impact on all soil-forming factors during the anthropocene. *ACS Environmental Au*, 2(1), 11-19. <https://doi.org/10.1021/acsenvironau.1c00010>.
- Dudley, N., & Alexander, S. (2017). Agriculture and biodiversity: a review. *Biodiversity*, 18(2-3), 45-49. <https://doi.org/10.1080/14888386.2017.1351892>.

- Eagleson, P. S. (1991). Hydrologic science: A distinct geoscience. *Reviews of Geophysics*, 29(2), 237-248. <https://doi.org/10.1029/90RG02615>.
- Eagleson, P. S. (1979). The annual water balance. *Journal of the Hydraulics Division*, 105(8), 921-941.
- Ehrenschaft, M., & Brambl, R. (1990). Respiration and mitochondrial biogenesis in germinating embryos of maize. *Plant Physiology*, 93(1), 295-304. <https://doi.org/10.1104/PP.93.1.295>.
- Elouafi, I. (2024). Why biodiversity matters in agriculture and food systems. *Science*, 386(6718), eads8197. <https://doi.org/10.1126/science.ads8197>.
- Ernest, S. M., Enquist, B. J., Brown, J. H., Charnov, E. L., Gillooly, J. F., Savage, V. M., ... & Tiffney, B. (2003). Thermodynamic and metabolic effects on the scaling of production and population energy use. *Ecology Letters*, 6(11), 990-995. <https://doi.org/10.1046/J.1461-0248.2003.00526.X>.
- Etherington, J. R. (1982). *Environment and plant ecology* (p. 481pp). <https://doi.org/10.2307/2258789>.
- Fageria, N. K. (2012). Role of soil organic matter in maintaining sustainability of cropping systems. *Communications in soil science and plant analysis*, 43(16), 2063-2113. <https://doi.org/10.1080/00103624.2012.697234>.
- Fattorini, R., & Glover, B. J. (2020). Molecular mechanisms of pollination biology. *Annual review of plant biology*, 71(1), 487-515. <https://doi.org/10.1146/annurev-arplant-081519-040003>.
- Ficiciyan, A., Loos, J., Sievers-Glotzbach, S., & Tschardtke, T. (2018). More than yield: Ecosystem services of traditional versus modern crop varieties revisited. *Sustainability*, 10(8), 2834. <https://doi.org/10.3390/SU10082834>.

- Figiel, S., Rusek, P., Ryszko, U., & Brodowska, M. S. (2025). Microbially Enhanced Biofertilizers: Technologies, Mechanisms of Action, and Agricultural Applications. *Agronomy*, 15(5), 1191. <https://doi.org/10.3390/agronomy15051191>.
- Francis, G., Edinger, R., & Becker, K. (2005, February). A concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India: Need, potential and perspectives of *Jatropha* plantations. In *Natural resources forum* (Vol. 29, No. 1, pp. 12-24). Oxford, UK: Blackwell Publishing, Ltd. <https://doi.org/10.1111/J.1477-8947.2005.00109.X>.
- Franzen, D. W., & Goos, R. J. (1999). *Soybean soil fertility*. NDSU Extension Service.
- Freund, M., Graus, D., Fleischmann, A., Gilbert, K. J., Lin, Q., Renner, T., ... & Fukushima, K. (2022). The digestive systems of carnivorous plants. *Plant physiology*, 190(1), 44-59. <https://doi.org/10.1093/plphys/kiac232>.
- Frison, E. A., Cherfas, J., & Hodgkin, T. (2011). Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability*, 3(1), 238-253. <https://doi.org/10.3390/SU3010238>.
- Garcia-Leon, M. A., Fuentes-Claramonte, P., Feria-Raposo, I., Valiente, A., Guerrero, A., Sarro, S., ... & Pomarol-Clotet, E. (2020). P. 834Hyperactivated brain response to fear and disgust in schizophrenia. *European Neuropsychopharmacology*, 40, S464-S465. <https://doi.org/10.1016/j.euroneuro.2020.09.603>.
- Gaillard, C., Langan, L., Pfeiffer, M., Kumar, D., Martens, C., Higgins, S. I., & Scheiter, S. (2018). African shrub distribution emerges via a trade-off between height and sapwood conductivity. *Journal of Biogeography*, 45(12), 2815-2826. <https://doi.org/10.1111/jbi.13447>.

- Gates, D. M. (1965). Energy, plants, and ecology. *Ecology*, 46(1-2), 1-13. <https://doi.org/10.2307/1935252>.
- Gelmi-Candusso, T. A., & Hämäläinen, A. M. (2019). Seeds and the city: the interdependence of zoochory and ecosystem dynamics in urban environments. *Frontiers in Ecology and Evolution*, 7, 41. <https://doi.org/10.3389/fevo.2019.00041>.
- Gerdel, R. W. (1938). Reciprocal relationships of texture, structure, and erosion on some residual soils. <https://doi.org/10.2136/SSSAJ1938.036159950002000C0085X>.
- Golley, F. B. (1968). Secondary productivity in terrestrial communities. *American Zoologist*, 8(1), 53-59. <https://doi.org/10.1093/ICB/8.1.53>.
- Gómez, J. M., Schupp, E. W., & Jordano, P. (2019). Synzoochory: the ecological and evolutionary relevance of a dual interaction. *Biological Reviews*, 94(3), 874-902. <https://doi.org/10.1111/brv.12481>.
- Götmark, F., Götmark, E., & Jensen, A. M. (2016). Why be a shrub? A basic model and hypotheses for the adaptive values of a common growth form. *Frontiers in Plant Science*, 7, 1095. <https://doi.org/10.3389/fpls.2016.01095>.
- Grace, J., & Thompson, J. R. (1973). The After-effect of Wind on the Photosynthesis and Transpiration of *Festuca arundinacea*. *Physiologia plantarum*, 28(3), 541-547. <https://doi.org/10.1111/J.1399-3054.1973.TB08603.X>.
- Gurner, R. (1998). Plant Ecology 2nd Edition. *Pacific Conservation Biology*, 4(2), 173. <https://doi.org/10.1071/PC980173>.
- Hall Cushman, J., Waller, J. C., & Hoak, D. R. (2010). Shrubs as ecosystem engineers in a coastal dune: influences on plant populations, communities and ecosystems. *Journal of Vegetation Science*, 21(5), 821-831. <https://doi.org/10.1111/J.1654-1103.2010.01196.X>.

- Harper, H. J. (1938). Factors which affect the development of prismatic structure in soils of the Southern Great Plains. <https://doi.org/10.2136/SSSAJ1938.036159950002000C0071X>.
- Hawkes, J. G. (1991). 1. The importance of genetic resources in plant breeding. *Biological journal of the linnean society*, 43(1), 3-10. <https://doi.org/10.1111/J.1095-8312.1991.TB00578.X>.
- He, Q. (2021). Biotic interactions and ecosystem dynamics under global change: from theory to application. *Chinese Journal of Plant Ecology*, 45(10), 1075. <https://doi.org/10.17521/cjpe.2020.0055>.
- Hedrich, R. (2015). Carnivorous plants. *Current Biology*, 25(3), R99-R100. <https://doi.org/10.1016/j.cub.2014.11.036>.
- Henderson, S., Dawson, T. P., & Whittaker, R. J. (2006). Progress in invasive plants research. *Progress in Physical Geography*, 30(1), 25-46. <https://doi.org/10.1191/0309133306PP468RA>.
- Hercher-Pasteur, J., Loiseau, E., Sinfort, C., & Hélias, A. (2020). Energetic assessment of the agricultural production system. A review. *Agronomy for Sustainable Development*, 40, 1-23. <https://doi.org/10.1007/s13593-020-00627-2>.
- Hillebrand, H., Bennett, D. M., & Cadotte, M. W. (2008). Consequences of dominance: a review of evenness effects on local and regional ecosystem processes. *Ecology*, 89(6), 1510-1520. <https://doi.org/10.1890/07-1053.1>.
- Ho, D. P., Ngo, H. H., & Guo, W. (2014). A mini review on renewable sources for biofuel. *Bioresource technology*, 169, 742-749. <https://doi.org/10.1016/j.biortech.2014.07.022>.
- Hochberg, U., Rockwell, F. E., Holbrook, N. M., & Cochard, H. (2018). Iso/anisohydry: a plant–environment interaction rather than a simple hydraulic trait. *Trends in plant*

- science*, 23(2), 112-120.
<https://doi.org/10.1016/j.tplants.2017.11.002>.
- Holmes, J. C. (1995). Population regulation: a dynamic complex of interactions. *Wildlife Research*, 22(1), 11-19.
<https://doi.org/10.1071/WR9950011>.
- Hooper, D. U., Chapin III, F. S., Ewel, J. J., Hector, A., Inchausti, P., Lavorel, S., ... & Wardle, D. A. (2005). Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecological monographs*, 75(1), 3-35.
<https://doi.org/10.1890/04-0922>.
- Howarth, R. W., Marino, R., Lane, J., & Cole, J. J. (1988). Nitrogen fixation in freshwater, estuarine, and marine ecosystems. 1. Rates and importance. *Limnology and Oceanography*, 33(4), 669-687.
<https://doi.org/10.4319/LO.1988.33.4PART2.0669>.
- Howe, H. F., & Smallwood, J. (1982). Ecology of seed dispersal. *Annual review of ecology and systematics*, 13, 201-228.
<https://doi.org/10.1146/ANNUREV.ES.13.110182.001221>.
- Huang, E., Chen, Y., & Yu, S. (2024). Climate factors drive plant distributions at higher taxonomic scales and larger spatial scales. *Frontiers in Ecology and Evolution*, 11, 1233936.
- Hull, J. C., Neufeld, H. S., & Gilliam, F. S. (2019). Plant Ecology- Introduction. *Encyclopedia of ecology*, 1-21.
<https://doi.org/10.1016/b978-0-12-409548-9.09135-1>.
- Huntly, N. (1991). Herbivores and the dynamics of communities and ecosystems. *Annual review of ecology and systematics*, 477-503.
<https://doi.org/10.1146/ANNUREV.ES.22.110191.002401>.
- Igwebuike, C. M., Awad, S., & Andrès, Y. (2024). Renewable energy potential: Second-generation biomass as feedstock for bioethanol production. *Molecules*, 29(7), 1619.
<https://doi.org/10.3390/molecules29071619>.

- Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A., & Anjum, S. A. (2020). Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agricultural Water Management*, 241, 106363. <https://doi.org/10.1016/j.agwat.2020.106363>.
- Iskandar, J., Iskandar, B. S., & Partasasmita, R. (2018). The impact of social and economic change on domesticated plant diversity with special reference to wet rice field and home-garden farming of West Java, Indonesia. *Biodiversitas Journal of Biological Diversity*, 19(2), 515-527. <https://doi.org/10.13057/BIODIV/D190227>.
- Jayanti, M., Hadihardadja, I. K., Dwi Ariesyady, H., & Messakh, J. J. (2020). Climate change impacts on hydrology regime and water resources sustainability in cimanuk watershed, West Java, Indonesia. *International Journal of Geomate*, 19(71), 90-97. <https://doi.org/10.21660/2020.71.9215>.
- Jethva, J., Schmidt, R. R., Sauter, M., & Selinski, J. (2022). Try or die: Dynamics of plant respiration and how to survive low oxygen conditions. *Plants*, 11(2), 205. <https://doi.org/10.3390/plants11020205>.
- Jokiel, P. L., & York Jr, R. H. (1984). Importance of ultraviolet radiation in photoinhibition of microalgal growth 1. *Limnology and Oceanography*, 29(1), 192-198. <https://doi.org/10.4319/LO.1984.29.1.0192>.
- Jouri, M. H. (2020). Food Security and Land Use Change under Conditions of Climatic Variability. *Journal of Rangeland Science*, 10(3), 357-357.
- Kabir, E., Hussain, D., Haque, A., & Kim, K. H. (2009). Prospects for biodiesel production from *Jatropha curcas*: a case study of Bangladesh Agricultural University Farm. *International Journal of Green Energy*, 6(4), 381-391. <https://doi.org/10.1080/15435070903107064>.

- Kaneko, K., Yokochi, M., Inoue, T., Kato, Y., & Fujita, H. (2024). Topographic conditions as governing factors of mire vegetation types analyzed from drone-based terrain model. *Journal of Vegetation Science*, 35(1), e13226. <https://doi.org/10.1111/jvs.13226>.
- Kannenbergh, S. A., Guo, J. S., Novick, K. A., Anderegg, W. R., Feng, X., Kennedy, D., ... & Matheny, A. M. (2022). Opportunities, challenges and pitfalls in characterizing plant water-use strategies. *Functional Ecology*, 36(1), 24-37. <https://doi.org/10.1111/1365-2435.13945>.
- Kaspar, T. C., & Bland, W. L. (1992). Soil temperature and root growth. *Soil Science*, 154(4), 290-299. <https://doi.org/10.1097/00010694-199210000-00005>.
- Keneni, G., Bekele, E., Imtiaz, M., & Dagne, K. (2012). Genetic vulnerability of modern crop cultivars: causes, mechanism and remedies. *International Journal of Plant Research*, 2(3), 69-79. <https://doi.org/10.5923/J.PLANT.20120203.05>.
- Kirkwood, R. S. M., & Lawton, J. H. (1981). Efficiency of biomass transfer and the stability of model food-webs. *Journal of Theoretical Biology*, 93(1), 225-237. [https://doi.org/10.1016/0022-5193\(81\)90067-9](https://doi.org/10.1016/0022-5193(81)90067-9).
- Kleidon, A., & Schymanski, S. (2008). Thermodynamics and optimality of the water budget on land: A review. *Geophysical Research Letters*, 35(20). <https://doi.org/10.1029/2008GL035393>.
- Koricheva, J., & Gurevitch, J. (2014). Uses and misuses of meta-analysis in plant ecology. *Journal of Ecology*, 102(4), 828-844. <https://doi.org/10.1111/1365-2745.12224>.
- Kozlovsky, D. G. (1968). A critical evaluation of the trophic level concept. I. Ecological efficiencies. *Ecology*, 49(1), 48-60. <https://doi.org/10.2307/1933560>.
- Kuypers, M. M., Marchant, H. K., & Kartal, B. (2018). The microbial nitrogen-cycling network. *Nature Reviews*

- Microbiology*, 16(5), 263-276.
<https://doi.org/10.1038/nrmicro.2018.9>.
- Kumagai, T. O., Yoshifuji, N., Tanaka, N., Suzuki, M., & Kume, T. (2009). Comparison of soil moisture dynamics between a tropical rain forest and a tropical seasonal forest in Southeast Asia: Impact of seasonal and year-to-year variations in rainfall. *Water Resources Research*, 45(4).
<https://doi.org/10.1029/2008WR007307>.
- Kumar, V., & Mohan Jain, S. (2014). Plants and algae species: Promising renewable energy production source. *Emirates Journal of Food & Agriculture (EJFA)*, 26(8).
<https://doi.org/10.9755/EJFA.V26I8.18364>.
- Kume, A. (2017). Importance of the green color, absorption gradient, and spectral absorption of chloroplasts for the radiative energy balance of leaves. *Journal of plant research*, 130(3), 501-514.
<https://doi.org/10.1007/s10265-017-0910-z>.
- Lasanta Martínez, T., Vicente Serrano, S. M., & Romo, A. (2004). Influencia de la topografía en la estacionalidad de la actividad vegetal: análisis en el Pirineo Occidental aragonés a partir de imágenes NOAA-AVHRR.
- Layman, C. A., & Allgeier, J. E. (2020). An ecosystem ecology perspective on artificial reef production. *Journal of Applied Ecology*, 57(11), 2139-2148.
<https://doi.org/10.1111/1365-2664.13748>.
- Levin, S. A., & Paine, R. T. (1974). Disturbance, patch formation, and community structure. *Proceedings of the National Academy of Sciences*, 71(7), 2744-2747. <https://doi.org/10.1073/PNAS.71.7.2744>.
- Light-Dependent Reactions of Photosynthesis, *The Plant Cell*, Volume 27, Issue 11, November 2015, tpc.115.tt1115, <https://doi.org/10.1105/tpc.115.tt1115>.

- Liu, C., Liao, X., Qiu, J., Yang, Y., Feng, X., Allan, R. P., ... & Xu, J. (2020). Observed variability of intertropical convergence zone over 1998—2018. *Environmental Research Letters*, 15(10), 104011. <https://doi.org/10.1088/1748-9326/aba033>.
- Long, I. F. (1957). Instruments for micro-meteorology. *Quarterly Journal of the Royal Meteorological Society*, 83(356), 202-214. <https://doi.org/10.1002/QJ.49708335607>.
- Loreti, E., & Perata, P. (2020). The many facets of hypoxia in plants. *Plants*, 9(6), 745. <https://doi.org/10.3390/plants9060745>.
- Lybrand, R. A. (2023). Connecting soils to life in conservation planning, nutrient cycling, and planetary science. *Earth-Science Reviews*, 237, 104247. <https://doi.org/10.1016/j.earscirev.2022.104247>.
- Lynn, W.S., & Strauss, E.G. (1961). Ecology. *Outlook on Agriculture*, 3, 102-102. <https://doi.org/10.1177/003072706100300301>.
- Magnusson, T. (1992). Studies of the soil atmosphere and related physical site characteristics in mineral forest soils. *Journal of Soil Science*, 43(4), 767-790. <https://doi.org/10.1111/J.1365-2389.1992.TB00176.X>.
- Martínez-Espinosa, R. M., Cole, J. A., Richardson, D. J., & Watmough, N. J. (2011). Enzymology and ecology of the nitrogen cycle. *Biochemical society transactions*, 39(1), 175-178. <https://doi.org/10.1042/BST0390175>.
- Masrahi, Y. S., Al-Turki, T. A., & Sayed, O. H. (2015). Photosynthetic adaptation and survival strategy of *Duvalia velutina* in an extremely arid environment. *Photosynthetica*, 53, 555-561. <https://doi.org/10.1007/s11099-015-0143-0>.

- McLaughlin, D. (1995). Recent developments in hydrologic data assimilation. *Reviews of Geophysics*, 33(S2), 977-984. <https://doi.org/10.1029/95RG00740>.
- Mehner, T., Lischke, B., Scharnweber, K., Attermeyer, K., Brothers, S., Gaedke, U., ... & Brucet, S. (2018). Empirical correspondence between trophic transfer efficiency in freshwater food webs and the slope of their size spectra. *Ecology*, 99(6), 1463-1472. <https://doi.org/10.1002/ecy.2347>.
- Mikkelsen, G. M., & Leibold, M. A. (1995). A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts. *Perspectives in Biology and Medicine*, 38(2), 297-299. <https://doi.org/10.1353/PBM.1995.0034>.
- Miller, W. (2008). The hierarchical structure of ecosystems: connections to evolution. *Evolution: Education and Outreach*, 1, 16-24. <https://doi.org/10.1007/s12052-007-0016-5>.
- Mittal, A., & Decker, S. R. (2013). Application of biotechnology for biofuels: transforming biomass to biofuels. *3 Biotech*, 3(5), 341-343. <https://doi.org/10.1007/s13205-013-0122-8>.
- Monteith, J. L. (1972). Solar radiation and productivity in tropical ecosystems. *Journal of applied ecology*, 9(3), 747-766. <https://doi.org/10.2307/2401901>.
- Mosley, L. M., Rengasamy, P., & Fitzpatrick, R. (2024). Soil pH: Techniques, challenges and insights from a global dataset. *European Journal of Soil Science*, 75(6), e70021. <https://doi.org/10.1111/ejss.70021>.
- Mougi, A., & Kondoh, M. (2012). Diversity of interaction types and ecological community stability. *Science*, 337(6092), 349-351. <https://doi.org/10.1126/science.1220529>.

- Murdoch, W. W. (1994). Population regulation in theory and practice. *Ecology*, 75(2), 271-287. <https://doi.org/10.2307/1939533>.
- Nagata, Y., Usui, K., & Bonn, M. (2015). Molecular mechanism of water evaporation. *Physical review letters*, 115(23), 236102. <https://doi.org/10.1103/PhysRevLett.115.236102>.
- Narsai, R., Law, S. R., Carrie, C., Xu, L., & Whelan, J. (2011). In-depth temporal transcriptome profiling reveals a crucial developmental switch with roles for RNA processing and organelle metabolism that are essential for germination in Arabidopsis. *Plant physiology*, 157(3), 1342-1362. <https://doi.org/10.1104/pp.111.183129>.
- Nawkar, G. M., Maibam, P., Park, J. H., Sahi, V. P., Lee, S. Y., & Kang, C. H. (2013). UV-induced cell death in plants. *International journal of molecular sciences*, 14(1), 1608-1628. <https://doi.org/10.3390/ijms14011608>.
- Neina, D. (2019). The role of soil pH in plant nutrition and soil remediation. *Applied and environmental soil science*, 2019(1), 5794869. <https://doi.org/10.1155/2019/5794869>.
- Niklas, K. J., & Hammond, S. T. (2019). Biophysical effects on the scaling of plant growth, form, and ecology. *Integrative and Comparative Biology*, 59(5), 1312-1323. <https://doi.org/10.1093/icb/icz028>.
- Norberg, J. (2004). Biodiversity and ecosystem functioning: a complex adaptive systems approach. *Limnology and Oceanography*, 49(4part2), 1269-1277. https://doi.org/10.4319/lo.2004.49.4_part_2.1269.
- Odum, E. P. (1977). The Emergence of Ecology as a New Integrative Discipline: Ecology must combine holism with reductionism if applications are to benefit society. *Science*, 195(4284), 1289-1293. <https://doi.org/10.1126/science.195.4284.1289>.

- Oh, N. H., Kim, H. S., & Richter Jr, D. D. (2005). What regulates soil CO₂ concentrations? A modeling approach to CO₂ diffusion in deep soil profiles. *Environmental Engineering Science*, 22(1), 38-45.
<https://doi.org/10.1089/EES.2005.22.38>.
- Or, D., Lehmann, P., Shahraeeni, E., & Shokri, N. (2013). Advances in soil evaporation physics—A review. *Vadose Zone Journal*, 12(4), vzj2012-0163. <https://doi.org/10.2136/VZJ2012.0163>.
- Outlaw, Jr, W. H. (2003). Integration of cellular and physiological functions of guard cells. *Critical Reviews in Plant Sciences*, 22(6), 503-529.
<https://doi.org/10.1080/713608316>.
- Pértile, P., Reichert, J. M., Gubiani, P. I., Holthusen, D., & Costa, A. D. (2016). Rheological parameters as affected by water tension in subtropical soils. *Revista Brasileira de ciência do solo*, 40(00), e0150286.
<https://doi.org/10.1590/18069657RBCS20150286>.
- Philippot, L., Griffiths, B. S., & Langenheder, S. (2021). Microbial community resilience across ecosystems and multiple disturbances. *Microbiology and Molecular Biology Reviews*, 85(2), 10-1128.
<https://doi.org/10.1128/MMBR.00026-20>.
- Phoon, W. O. (1989). Ecology and public health. *Asia Pacific Journal of Public Health*, 3(3), 183-183.
<https://doi.org/10.1177/101053958900300301>.
- Poorter, L., Amissah, L., Bongers, F., Hordijk, I., Kok, J., Laurance, S. G., ... & van der Sande, M. T. (2023). Successional theories. *Biological Reviews*, 98(6), 2049-2077.
<https://doi.org/10.1111/brv.12995>.
- Poulos, H. M., & Camp, A. E. (2010). Topographic influences on vegetation mosaics and tree diversity in the Chihuahuan

- Desert Borderlands. *Ecology*, 91(4), 1140-1151.
<https://doi.org/10.1890/08-1808.1>.
- POURBABAEI, H., & HAGHGOOY, T. (2012). Plant species diversity in the ecological species groups in the Kandelat Forest Park, Guilan, North of Iran. *Biodiversitas Journal of Biological Diversity*, 13(1).
<https://doi.org/10.13057/BIODIV/D130102>.
- Power, A. G. (2010). Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical transactions of the royal society B: biological sciences*, 365(1554), 2959-2971.
<https://doi.org/10.1098/rstb.2010.0143>.
- Pyšek, P., & Chytrý, M. (2014). Habitat invasion research: where vegetation science and invasion ecology meet. *Journal of Vegetation Science*, 25(5), 1181-1187.
<https://doi.org/10.1111/JVS.12146>.
- Rai, P. K. (2016). Impacts of particulate matter pollution on plants: Implications for environmental biomonitoring. *Ecotoxicology and environmental safety*, 129, 120-136. <https://doi.org/10.1016/j.ecoenv.2016.03.012>.
- Rashid, A., Schutte, B. J., Ulery, A., Deyholos, M. K., Sanogo, S., Lehnhoff, E. A., & Beck, L. (2023). Heavy metal contamination in agricultural soil: environmental pollutants affecting crop health. *Agronomy*, 13(6), 1521.
<https://doi.org/10.3390/agronomy13061521>.
- Richardson, D. (2011). From Observations to Forecasts—Part 11: Ensemble products for weather forecasters. *Weather*, 66(9), 235-241. <https://doi.org/10.1002/wea.845>.
- Riddoch, I., Monteith, J. L., Scott, R. K., & Unsworth, M. H. (1995). Resource Capture by Crops. *Journal of Applied Ecology*, 32(3), 670. <https://doi.org/10.2307/2404664>.
- Risser, P. G. (1995). Biodiversity and ecosystem function. *Conservation Biology*, 9(4), 742-746.
<https://doi.org/10.1046/J.1523-1739.1995.09040742.X>.

- Risser, P. G. (1989). Ecology and Our Endangered Life-Support Systems. *BioScience*, 39(11), 814-816.
- Riyazuddin, R., Nisha, N., Ejaz, B., Khan, M. I. R., Kumar, M., Ramteke, P. W., & Gupta, R. (2021). A comprehensive review on the heavy metal toxicity and sequestration in plants. *Biomolecules*, 12(1), 43. <https://doi.org/10.3390/biom12010043>.
- Rockwell, F. E., Holbrook, N. M., & Stroock, A. D. (2014). The competition between liquid and vapor transport in transpiring leaves. *Plant Physiology*, 164(4), 1741-1758. <https://doi.org/10.1104/pp.114.236323>.
- Roxburgh, S. H., Berry, S. L., Buckley, T. N., Barnes, B., & Roderick, M. L. (2005). What is NPP? Inconsistent accounting of respiratory fluxes in the definition of net primary production. *Functional Ecology*, 19(3), 378-382. <https://doi.org/10.1111/J.1365-2435.2005.00983.X>.
- Ruangpanit, N. (1995). Tropical seasonal forests in monsoon Asia: With emphasis on continental southeast Asia. *Vegetatio*, 121, 31-40. https://doi.org/10.1007/978-94-011-0343-5_4.
- Rutledge, R. W., Basore, B. L., & Mulholland, R. J. (1976). Ecological stability: an information theory viewpoint. *Journal of Theoretical Biology*, 57(2), 355-371. [https://doi.org/10.1016/0022-5193\(76\)90007-2](https://doi.org/10.1016/0022-5193(76)90007-2).
- Saavedra, S., Cenci, S., del-Val, E., Boege, K., & Rohr, R. P. (2017). Reorganization of interaction networks modulates the persistence of species in late successional stages. *Journal of Animal Ecology*, 86(5), 1136-1146. <https://doi.org/10.1111/1365-2656.12710>.
- Sairam, R. K., Kumutha, D., Ezhilmathi, K., Deshmukh, P. S., & Srivastava, G. C. (2008). Physiology and biochemistry of waterlogging tolerance in plants. *Biologia plantarum*, 52(3), 401-412. <https://doi.org/10.1007/s10535-008-0084-6>.

- Savenije, H. H. (2004). The importance of interception and why we should delete the term evapotranspiration from our vocabulary. <https://doi.org/10.1002/hyp.5563>.
- Schreuder, M. D., Brewer, C. A., & Heine, C. (2001). Modelled influences of non-exchanging trichomes on leaf boundary layers and gas exchange. *Journal of theoretical biology*, 210(1), 23-32. <https://doi.org/10.1006/JTBI.2001.2285>.
- Sears, P.B. (1971). Ecology. Science. <https://doi.org/10.1126/science.174.4007.360.c>.
- Schumacher, C., & Houze Jr, R. A. (2003). Stratiform rain in the tropics as seen by the TRMM precipitation radar. *Journal of climate*, 16(11), 1739-1756. [https://doi.org/10.1175/1520-0442\(2003\)016<1739:SRITTA>2.0.CO;2](https://doi.org/10.1175/1520-0442(2003)016<1739:SRITTA>2.0.CO;2).
- Sexton, J. P., & Dickman, E. E. (2016). What can local and geographic population limits tell us about distributions?. *American Journal of Botany*, 103(1), 129-139. <https://doi.org/10.3732/ajb.1500224>.
- Sharma, R. K., & Agrawal, M. (2005). Biological effects of heavy metals: an overview. *Journal of environmental Biology*, 26(2), 301-313.
- Shestopaloff, Y. K. (2016). Metabolic allometric scaling model: Combining cellular transportation and heat dissipation constraints. *Journal of Experimental Biology*, 219(16), 2481-2489. <https://doi.org/10.1242/jeb.138305>.
- Shive Jr, J. B., & Brown, K. W. (1978). Quaking and gas exchange in leaves of cottonwood (*Populus deltoides*, Marsh.). *Plant Physiology*, 61(3), 331-333. <https://doi.org/10.1104/PP.61.3.331>.
- Sinclair, A. R. E. (1975). The resource limitation of trophic levels in tropical grassland ecosystems. *The Journal of Animal Ecology*, 497-520. <https://doi.org/10.2307/3608>.
- Slattery, R. A., & Ort, D. R. (2015). Photosynthetic energy conversion efficiency: setting a baseline for gauging future

- improvements in important food and biofuel crops. *Plant physiology*, 168(2), 383-392. <https://doi.org/10.1104/pp.15.00066>.
- Smith, P., Ashmore, M. R., Black, H. I., Burgess, P. J., Evans, C. D., Quine, T. A., ... & Orr, H. G. (2013). The role of ecosystems and their management in regulating climate, and soil, water and air quality. *Journal of Applied Ecology*, 50(4), 812-829. <https://doi.org/10.1111/1365-2664.12016>.
- Strangeways, I. (2003). The 'met. enclosure': Part 9 (a)—Automatic weather stations: Temperature, humidity, barometric pressure and wind. *Weather*, 58(11), 428-434. <https://doi.org/10.1256/wea.81.03A>.
- Sun, H., Niu, Y., CHEN, Y. S., Song, B., LIU, C. Q., PENG, D. L., ... & Yang, Y. A. N. G. (2014). Survival and reproduction of plant species in the Qinghai-Tibet Plateau. *Journal of Systematics and Evolution*, 52(3), 378-396. <https://doi.org/10.1111/jse.12092>.
- Targulian, V. O. (2001). Pedogenesis and the lithosphere. *Eurasian soil science*, 34, S21-S27.
- Tatum, L. A. (1971). The Southern Corn Leaf Blight Epidemic: A new race of the fungus *Helminthosporium maydis* threatens domestic prices and corn reserves for export. *Science*, 171(3976), 1113-1116. <https://doi.org/10.1126/science.171.3976.1113>.
- Terradas, J., & Penuelas, J. (2011). Misleading ideas about top-down and bottom-up control in communities and the role of omnivores. *Polish Journal of Ecology*, 59(4), 849-850.
- Thatoi, H., Dash, P. K., Mohapatra, S., & Swain, M. R. (2016). Bioethanol production from tuber crops using fermentation technology: a review. *International Journal of Sustainable Energy*, 35(5), 443-468. <https://doi.org/10.1080/14786451.2014.918616>.

- Thepbandit, W., & Athinuwat, D. (2024). Rhizosphere microorganisms supply availability of soil nutrients and induce plant defense. *Microorganisms*, 12(3), 558. Taylor, W. P. (1936). What is ecology and what good is it?. *Ecology*, 17(3), 333-346. <https://doi.org/10.2307/1931838>.
- Thepbandit, W., & Athinuwat, D. (2024). Rhizosphere microorganisms supply availability of soil nutrients and induce plant defense. *Microorganisms*, 12(3), 558. <https://doi.org/10.3390/microorganisms12030558>.
- Thrupp, L. A. (2004). The importance of biodiversity in agroecosystems. *Journal of Crop Improvement*, 12(1-2), 315-337. https://doi.org/10.1300/J411v12n01_03.
- Tibbitts, T. W. (1979). Humidity and plants. *BioScience*, 29(6), 358-363. <https://doi.org/10.2307/1307692>.
- Torres, L. C., Keller, T., de Lima, R. P., Tormena, C. A., de Lima, H. V., & Giarola, N. F. B. (2021). Impacts of soil type and crop species on permanent wilting of plants. *Geoderma*, 384, 114798. <https://doi.org/10.1016/j.geoderma.2020.114798>.
- Tuomisto, H. (2012). An updated consumer's guide to evenness and related indices. *Oikos*, 121(8), 1203-1218. <https://doi.org/10.1111/J.1600-0706.2011.19897.X>.
- Ulanowicz, R. E. (1972). Mass and energy flow in closed ecosystems. *Journal of Theoretical Biology*, 34(2), 239-253. [https://doi.org/10.1016/0022-5193\(72\)90158-0](https://doi.org/10.1016/0022-5193(72)90158-0).
- Valente, I. D. L., Wancura, J. H., Zabot, G. L., & Mazutti, M. A. (2025). Endophytic and Rhizospheric Microorganisms: An Alternative for Sustainable, Organic, and Regenerative Bioinput Formulations for Modern Agriculture. *Microorganisms*, 13(4), 813. <https://doi.org/10.3390/microorganisms13040813>.

- Van Lenteren, J. C., & Overholt, W. A. (1994). Ecology and integrated pest management. *International Journal of Tropical Insect Science*, 15(6), 557-582. <https://doi.org/10.1017/S174275840001688X>.
- Veblen, K. E., Nehring, K. C., McGlone, C. M., & Ritchie, M. E. (2015). Contrasting effects of different mammalian herbivores on sagebrush plant communities. *PLoS One*, 10(2), e0118016. <https://doi.org/10.1371/journal.pone.0118016>.
- Veihmeyer, F. J., & Hendrickson, A. H. (1927). Soil-moisture conditions in relation to plant growth. *Plant physiology*, 2(1), 71. <https://doi.org/10.1104/PP.2.1.71>.
- Verhoeven, J. T., & Sorrell, B. K. (2010). Plant adaptations and microbial processes in wetlands. *Annals of botany*, 105(1), 127-127. <https://doi.org/10.1093/aob/mcp266>.
- Vitousek, P. M., Menge, D. N., Reed, S. C., & Cleveland, C. C. (2013). Biological nitrogen fixation: rates, patterns and ecological controls in terrestrial ecosystems. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 368(1621), 20130119. <https://doi.org/10.1098/rstb.2013.0119>.
- Walker, B. (1995). Conserving biological diversity through ecosystem resilience. *Conservation biology*, 9(4), 747-752. <https://doi.org/10.1046/J.1523-1739.1995.09040747.X>.
- White, C. R., Alton, L. A., Bywater, C. L., Lombardi, E. J., & Marshall, D. J. (2022). Metabolic scaling is the product of life-history optimization. *Science*, 377(6608), 834-839. <https://doi.org/10.1126/science.abm7649>.
- White, C. R., & Kearney, M. R. (2011). Metabolic scaling in animals: methods, empirical results, and theoretical explanations. *Comprehensive Physiology*, 4(1), 231-256. <https://doi.org/10.1002/cphy.c110049>.
- Wilcox, G. E., & Pfeiffer, C. L. (1990). Temperature effect on seed germination, seedling root development and growth

- of several vegetables. *Journal of plant nutrition*, 13(11), 1393-1403. <https://doi.org/10.1080/01904169009364161>.
- Wigley, B. J., Fritz, H., Coetsee, C., & Bond, W. J. (2013). Herbivores shape woody plant communities in the Kruger National Park: lessons from three long-term exclosures. <https://doi.org/10.4102/KOEDOE.V56I1.1165>.
- Wilsey, B. J., & Potvin, C. (2000). Biodiversity and ecosystem functioning: importance of species evenness in an old field. *Ecology*, 81(4), 887-892. [https://doi.org/10.1890/0012-9658\(2000\)081\[0887:BAEFIO\]2.0.CO;2](https://doi.org/10.1890/0012-9658(2000)081[0887:BAEFIO]2.0.CO;2).
- Woodwell, G. M., & Whittaker, R. H. (1968). Primary production in terrestrial ecosystems. *American Zoologist*, 8(1), 19-30. <https://doi.org/10.1093/ICB/8.1.19>.
- Yamaguchi, M., Flocker, W. J., & Howard, F. D. (1967). Soil atmosphere as influenced by temperature and moisture. *Soil Science Society of America Journal*, 31(2), 164-167. <https://doi.org/10.2136/SSSAJ1967.03615995003100020008X>.
- Yeakel, J. D., Pires, M. M., de Aguiar, M. A., O'Donnell, J. L., Guimarães Jr, P. R., Gravel, D., & Gross, T. (2020). Diverse interactions and ecosystem engineering can stabilize community assembly. *Nature communications*, 11(1), 3307. <https://doi.org/10.1038/s41467-020-17164-x>.
- Yoshida, K., Schuenemann, V. J., Cano, L. M., Pais, M., Mishra, B., Sharma, R., ... & Burbano, H. A. (2013). The rise and fall of the *Phytophthora infestans* lineage that triggered the Irish potato famine. *elife*, 2, e00731. <https://doi.org/10.7554/eLife.00731>.
- Yu, T., & Zhuang, Q. (2020). Modeling biological nitrogen fixation in global natural terrestrial ecosystems. *Biogeosciences*, 17(13), 3643-3657. <https://doi.org/10.5194/bg-17-3643-2020>.

Zhu, F. M., An, S. Q., Guan, B. H., Liu, Y. H., Zhou, C. F., & Wang, Z. S. (2007). A review of ecotone: concepts, attributes, theories and research advances. *Acta Ecologica Sinica*, 27(7), 3032-3042.

PROFIL PENULIS



Rosnina AG

Lahir pada tanggal 16 Juni 1965 di Aceh Timur, Provinsi Aceh. Penulis menyelesaikan pendidikan Sekolah Dasar di SD Swasta Mendaris A. Tebing Tinggi Deli Sumatera Utara tahun 1977, Sekolah Menengah Pertama di SMPN-VI Banda Aceh tahun 1981, dan Sekolah Menengah Atas di SPP SNak-MA Negeri Saree Aceh tahun 1984. Pada tahun yang sama penulis diterima bekerja pada Lembaga Sosial Masyarakat BKPSM Save the Children di Impact Area Tangse s.d 1985. Pada pertengahan Juni tahun 1985 s.d awal 1988 bekerja pada Unit Rehabilitasi Rumah Sakit Jiwa Pekanbaru. September 1988 bekerja di Biro Akademik unit Registrasi Universitas Malikussaleh, dan pada tahun yang sama penulis melanjutkan pendidikan di Fakultas Pertanian dan menyelesaikan pendidikan Strata-1 pada Program Studi Agronomi Fakultas Pertanian Universitas Malikussaleh tahun 1995. Setelah menamatkan pendidikan Strata-1, awal tahun 1997 Penulis mulai mengajar pada program studi Agronomi Fakultas Pertanian Universitas Malikussaleh s.d sekarang. Pada tahun

1999-2003 Penulis mengikuti pendidikan jenjang Strata-2 pada Program Studi Konservasi Sumberdaya Lahan Fakultas Pertanian Universitas Syiah Kuala Banda Aceh dan pada tahun 2006 melanjutkan pendidikan di Universitas Putra Malaysia pada prodi Proteksi Tanaman hanya 1 tahun. Pada tahun 2007 penulis kembali melanjutkan pendidikan pada program Doctoral di Fakultas Sains Biologi dengan konsentrasi Mushroom Bioteknologi Universiti Malaya Kuala Lumpur. Penulis telah dinyatakan lulus Viva (ujian sidang) pada Desember 2016. Oleh karena tidak dapat memperoleh sertifikat IELTS dengan band score 5.5 sebagai persyaratan kelulusan, penulis tidak diperbolehkan melanjutkan proses pengurusan ijazahnya. Penulis mengasuh mata kuliah Biologi, Genetika, Ekologi, Agrotechnopreneurshi, Teknik pengolahan hasil pertanian, Konservasi Tanah dan Air. Sejak tahun 2017 Penulis dipercaya mengelola jurnal sebagai Editor in Chief Jurnal Agrium Prodi Agroekoteknologi Fakultas Pertanian Universitas Malikussaleh. Pada tahun 2025 penulis melanjutkan pendidikan pada program Doktor Ilmu Pertanian Universitas Syiah Kuala Banda Aceh.

Email penulis: rosnina@unimal.ac.id