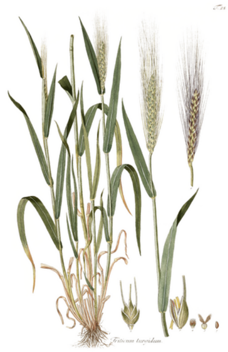
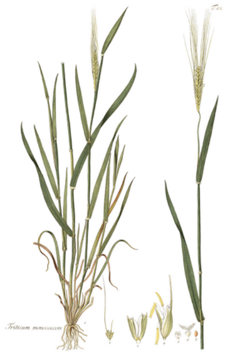
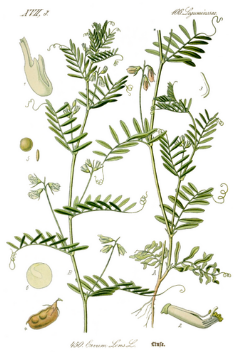
Founder crops

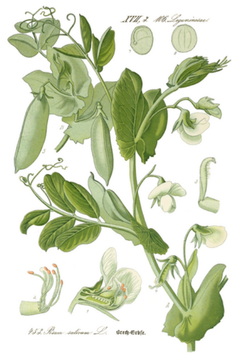
The **founder crops** or **primary domesticates** are a group of flowering plants that were domesticated by early farming communities in Southwest Asia and went on to form the basis of agricultural economies across Eurasia. As originally defined by Daniel Zohary and Maria Hopf, they consisted of three cereals (emmer wheat, einkorn wheat, and barley), four pulses (lentil, pea, chickpea, and bitter vetch), and flax. Subsequent research has indicated that many other species could be considered founder crops. These species were amongst the first domesticated plants in the world.

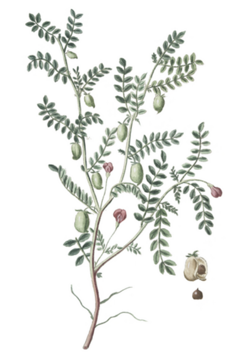

Emmer wheat
Triticum turgidum subsp. *dicoccum*

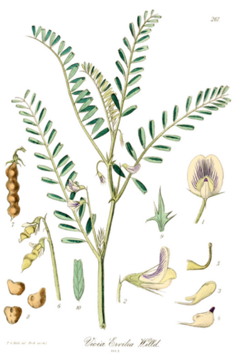

Einkorn wheat
Triticum monococcum

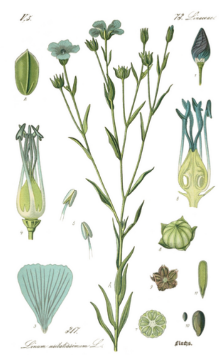

Barley
Hordeum vulgare


Lentil
Lens culinaris


Pea
Pisum sativum


Chickpea
Cicer arietinum


Bitter vetch
Vicia ervilia


Flax
Linum usitatissimum

Definition

In 1988, the Israeli botanist Daniel Zohary and the German botanist Maria Hopf formulated their founder crops hypothesis. They proposed that eight plant species were domesticated by early Neolithic farming communities in Southwest Asia (Fertile Crescent) and went on to form the basis of agricultural economies across much of Eurasia, including Southwest Asia, South Asia, Europe, and North Africa, in a single process.[1][2] The founder crops consisted of three cereals (emmer wheat, einkorn wheat, and barley), four pulses (lentil, pea, chickpea, and bitter vetch), and flax. They were amongst the first domesticated plants in the world.[3] These founder crops were domesticated in the Pre-Pottery Neolithic period,[4] between 10,500 and 7,500 years ago.[5]

Different species formed the basis of early agricultural economies in other centres of domestication. For example, rice was first cultivated in the Yangtze River basin of East Asia in the early Neolithic.[6][7] Sorghum was widely cultivated in sub-Saharan Africa during the early Neolithic,[8] while peanuts,[9] squash,[10] and cassava[11] were domesticated in the Americas.[12]

Domestication

All of the so-called founder crops are native to Southwest Asia and were domesticated in the Pre-Pottery Neolithic period.[4][5] Many other crops were domesticated in West Asia during the Neolithic, as well as elsewhere, independently, in later periods.[13]

Cereals

The staple crops of Neolithic agriculture were cereals, which could be easily cultivated in open fields, have a high nutritional value, and can be stored for long periods of time. The most important were two species of wheat, namely emmer (*Triticum turgidum* subsp. *dicoccum*) and einkorn (*Triticum monococcum*) and barley (*Hordeum vulgare*), which were amongst the first species to be domesticated in the world. The wild progenitors of all three crops are self-pollinating, which made them easier to domesticate.[14]

Wild einkorn wheat (*Triticum monococcum* subsp. *boeoticum*) grows across Southwest Asia in open parkland and steppe environments.[14] It comprises three distinct races, only one of which, native to Southeast Anatolia, was domesticated.[15] The main feature that distinguishes domestic einkorn from wild is that its ears will not shatter without pressure, making it dependent on humans for dispersal and reproduction.[14] It also tends to have wider grains.[14] Wild einkorn was collected at Epipalaeolithic sites such as Tell Abu Hureyra (c. 12,700–11,000 years ago) and Mureybet (c. 11,800–11,300 years ago), but the earliest archaeological evidence for the domestic form comes from the early Pre-Pottery Neolithic B of southern Turkey, at Çayönü, Cafer Höyük, and possibly Nevalı Çori.[14] Genetic evidence indicates that it was domesticated in multiple places independently.[15]

Wild emmer wheat (*Triticum turgidum* subsp. *dicoccoides*) is less widespread than einkorn, favouring the rocky basaltic and limestone soils found in the hilly flanks of the Fertile Crescent.[14] It is also more diverse, with domesticated varieties falling into two major groups: hulled or non-shattering, in which threshing separates the whole spikelet; and free-threshing, where the individual grains are separated. Both varieties probably existed in the Neolithic, but over time free-threshing cultivars became more common.[14] Genetic studies have found that, like einkorn, emmer was domesticated in southeastern Anatolia, but only once.[16][17] The earliest secure archaeological evidence for domestic emmer comes from the early PPNB levels at Çayönü, c. 10,250–9550 years ago, where distinctive scars on the spikelets indicated that they came from a hulled domestic variety.[14] Slightly earlier finds have been reported from Tell Aswad in Syria, c. 10,500–10,200 years ago, but these were identified using a less reliable method based on grain size.[14]

Wild barley (*Hordeum spontaneum*) is more widely distributed than either wheat species, growing across the Eastern Mediterranean, Southwest Asia, and as far east as Tibet, but is most common in the Fertile Crescent.[14] Its tolerance for dry conditions and poor soils allows it to thrive in arid steppe and desert environments.[14] Wild barley has two rows of spikelets, hulled grains, and a brittle rachis; domestication produced, successively, non-brittle, naked (hulless), and then six-rowed forms.[14] Genetic evidence indicates that it was first domesticated in the Fertile Crescent, probably in the Levant, though there may have been independent domestication events elsewhere.[18] Wild barley was harvested in Southwest Asia as long as 50,000 years ago at Kebara Cave, and 23,000 years ago at Ohalo II.[14] At Gilgal I, a Pre-Pottery Neolithic A site in Israel dated to c. 11,700–10,550 years ago, archaeologists discovered a large granary containing thousands of wild barley grains, providing direct evidence for the cultivation of a cereal before it was domesticated.[19] The earliest known remains of domesticated two-row barley come from Tell Aswad and are c. 10,200–9,550 years old.[14] Six-rowed barley is first seen at Çatalhöyük, c. 9350–8950 years ago, and naked varieties at Hacilar, c. 9350–8950 years ago.[14]

Pulses

- Lentil (*Lens culinaris*)
- Pea (*Pisum sativum*)
- Chickpea (*Cicer arietinum*)
- Bitter vetch (*Vicia ervilia*)

Flax

Flax (*Linum usitatissimum*) was the first species to be domesticated for oil and fibres rather than food.[20] Its wild progenitor was *Linum bienne*, which can be found from western Europe to the Caucasus.[20] Wild flax fibres were used by humans as early as 30,000 years ago, at Dzudzuana cave in Georgia,[21] but genetic evidence indicates that domestic flax was initially selected for its oil.[22][20] In Southwest Asia, the oldest known wild linseed comes from Tell Mureibit and is c. 11,800–11,300 years old; thereafter, it is commonly found at Pre-Pottery Neolithic B sites across the region.[20] These remains are thought to represent the collection of seeds for pressing or consumption, since flax fibres are usually harvested before the seeds mature.[20] Domestic flax is distinguished by its non-splitting capsules, larger seeds, higher oil yield, and longer fibres compared to wild varieties.[20] It does not appear in the archaeological record until relatively late, at Tell es-Sultan (Jericho), c. 9900–9550 years ago.[20]

Cultivation and spread

Epipalaeolithic hunter-gatherers harvested the wild ancestors of the "founder crops" for millennia before they were domesticated, perhaps as early as 23,000 years ago, but they formed a minor component of their diets.[23][24] Even after they were brought under cultivation, the founder crops were not favoured over wild plants, and they were not established as staple foods until the early Pre-Pottery Neolithic B period, c. 10,700–9700 years ago.[25][24] This phase of "pre-domestication cultivation" lasted at least a thousand years, during which early cultivars were spread around the region and slowly developed the traits that would come to characterise their domesticated forms.[26]

Other crops

The founder crops were not the only species domesticated in southwest Asia, nor were they necessarily the most important in the Neolithic period.[25] Domesticated rye (*Secale cereale*) occurs in the final Epipalaeolithic strata at Tell Abu Hureyra (the earliest instance of domesticated plant species),[27] but was not common until the spread of farming into northern Europe several millennia later.[28] Other plants cultivated in the Neolithic include sweet almond[29] and figs.[30]

As of 2018, many scholars disagreed with the "founder notion".[31] In 2012, scholars suggested that there were likely more than just 8 "founder crops", including 16 or 17 different species of cereals and legumes and figs. Larger DNA data sets and better analytical techniques suggest a more complex picture.[32] In 2000, a "new" glume wheat (NGW), a type of cultivated wheat which existed across western Asia and Europe was found in archeological sites of Hungary, then Turkey[33] and in 2023 in Bavaria, Germany.[34]

See also

- List of ancient dishes

Notes

1. Zohary, Daniel; Hopf, Maria (1988). *Domestication of plants in the old world*. Clarendon.
2. Harris, David R. (1996). *The Origin and Spread of Agriculture and Pastoralism in Eurasia*. London: University College London Press. pp. 142–158. ISBN 978-1-8572-8537-6.
3. Zohary, Hopf & Weiss 2012, p. 139.
4. Zohary, Hopf & Weiss 2012, "Current state of the art".
5. Banning 2002.
6. Normile, Dennis (1997). "Yangtze seen as earliest rice site". *Science*. **275** (5298): 309–310. doi:10.1126/science.275.5298.309 (https://doi.org/10.1126%2Fscience.275.5298.309). S2CID 140691699 (https://api.semanticscholar.org/CorpusID:140691699).
7. "New Archaeobotanic Data for the Study of the Origins of Agriculture in China", Zhijun Zhao, Current Anthropology Vol. 52, No. S4, (October 2011), pp. S295-S306
8. Carney, Judith (2009). *In the Shadow of Slavery*. Berkeley and Los Angeles, California: University of California Press. p. 16. ISBN 9780520269965.
9. Dillehay, Tom D. "Earliest-known evidence of peanut, cotton and squash farming found" (http://www.eurekalert.org/pub_releases/2007-06/vu-eeo062507.php). Archived (https://web.archive.org/web/20070911192923/http://www.eurekalert.org/pub_releases/2007-06/vu-eeo062507.php) from the original on September 11, 2007. Retrieved June 29, 2007.
10. Smith, Bruce D. (15 August 2006). "Eastern North America as an Independent Center of Plant Domestication" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1567861). *Proceedings of the National Academy of Sciences of the United States of America*. **103** (33): 12223–12228. Bibcode:2006PNAS..10312223S (https://ui.adsabs.harvard.edu/abs/2006PNAS..10312223S). doi:10.1073/pnas.0604335103 (https://doi.org/10.1073%2Fpnas.0604335103). PMC 1567861 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1567861). PMID 16894156 (https://pubmed.ncbi.nlm.nih.gov/16894156).
11. Olsen, Kenneth M.; Schaal, Barbara A. (1999-05-11). "Evidence on the origin of cassava: Phylogeography of Manihot esculenta" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC21904). *Proceedings of the National Academy of Sciences*. **96** (10): 5586–5591. Bibcode:1999PNAS...96.5586O (https://ui.adsabs.harvard.edu/abs/1999PNAS...96.5586O). doi:10.1073/pnas.96.10.5586 (https://doi.org/10.1073%2Fpnas.96.10.5586). ISSN 0027-8424 (https://search.worldcat.org/issn/0027-8424). PMC 21904 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC21904). PMID 10318928 (https://pubmed.ncbi.nlm.nih.gov/10318928).
12. Wilford, John Noble (28 June 2007). "Scientists Find Earliest Sign of Cultivated Crops in Americas" (https://www.nytimes.com/2007/06/28/science/28cnd-squash.html). *The New York Times*. Archived (https://web.archive.org/web/20201124052546/https://www.nytimes.com/2007/06/28/science/28cnd-squash.html) from the original on 24 November 2020. Retrieved 24 June 2020.
13. Purugganan, Michael D.; Fuller, Dorian Q. (1 February 2009). "The nature of selection during plant domestication" (https://www.researchgate.net/publication/24003450). *Nature*. **457** (7231). Springer: 843–848. Bibcode:2009Natur.457..843P (https://ui.adsabs.harvard.edu/abs/2009Natur.457..843P). doi:10.1038/nature07895 (https://doi.org/10.1038%2Fnature07895). ISSN 0028-0836 (https://search.worldcat.org/issn/0028-0836). PMID 19212403 (https://pubmed.ncbi.nlm.nih.gov/19212403). Archived (https://web.archive.org/web/20231020135832/https://www.researchgate.net/profile/Dorian-Fuller/publication/24003450_Purugganan_MD_Fuller_DQ_The_nature_of_selection_during_plant_domestication_Nature_457_843-848/links/0912f508156a26ca22000000/Purugganan-MD-Fuller-DQ-The-nature-of-selection-during-plant-domestication-Nature-457-843-848.pdf) (PDF) from the original on 20 October 2023. Retrieved 19 October 2023.
14. Zohary, Hopf & Weiss 2012, "Cereals".
15. Kilian et al. 2007.
16. Ozkan et al. 2002.
17. Luo et al. 2007.
18. Haas, Schreiber & Mascher 2018.
19. Weiss, Kislev & Hartmann 2006.
20. Zohary, Hopf & Weiss 2012, "Oil- and fibre- producing plants".
21. Kvavadze et al. 2009.
22. Allaby et al. 2005.
23. Richter & Maher 2013.
24. Arranz-Otaegui et al. 2018.
25. Arranz-Otaegui 2021.
26. Fuller, Willcox & Allaby 2011.
27. Hillman, Gordon; Hedges, Robert; Moore, Andrew; Colledge, Susan; Pettitt, Paul (2001). "New evidence of Lateglacial cereal cultivation at Abu Hureyra on the Euphrates" (https://www.researchgate.net/publication/200033056). *The Holocene*. **11** (4): 383–393. Bibcode:2001Holoc..11..383H (https://ui.adsabs.harvard.edu/abs/2001Holoc..11..383H). doi:10.1191/095968301678302823 (https://doi.org/10.1191%2F095968301678302823). ISSN 0959-6836 (https://search.worldcat.org/issn/0959-6836). S2CID 84930632 (https://api.semanticscholar.org/CorpusID:84930632). Archived (https://web.archive.org/web/20211120221734/https://www.researchgate.net/publication/200033056_New_evidence_of_Late_Glacial_cereal_cultivation_at_Abu_Hureyra_on_the_Euphrates) from the original on 2021-11-20. Retrieved 2023-06-25.
28. Hillman, Gordon (1996). "Climate-induced changes in the plant resources of hunter-gatherers of the northern Fertile Crescent: preludes to cereal cultivation?". In Harris, David R. (ed.). *The origins and spread of agriculture and pastoralism in Eurasia*. Routledge. ISBN 978-1-8572-8537-6.
29. Ladizinsky, G. (1999). "On the Origin of Almond". *Genetic Resources and Crop Evolution*. **46** (2): 143–147. doi:10.1023/A:1008690409554 (https://doi.org/10.1023%2FA%3A1008690409554). S2CID 25141013 (https://api.semanticscholar.org/CorpusID:25141013).
30. "Figs likely first domesticated crop" (https://news.harvard.edu/gazette/story/2006/06/figs-likely-first-domesticated-crop/). 8 June 2006.

31. Kris Hirst (2018-08-31). "Were There Really Only Eight Founder Crops in Farming History?" (https://www.thoughtco.com/founder-crops-origins-of-agriculture-171203). *ThoughtCo*. Archived (https://web.archive.org/web/20230525231331/https://www.thoughtco.com/founder-crops-origins-of-agriculture-171203) from the original on 2023-05-25. Retrieved 2023-05-25.
32. Fuller, Dorian Q.; Willcox, George; Allaby, Robin G. (January 2012). "Early agricultural pathways: moving outside the 'core area' hypothesis in Southwest Asia" (https://doi.org/10.1093%2Fjxb%2Ferr307). *Journal of Experimental Botany*. **63** (2): 617–633. doi:10.1093/jxb/err307 (https://doi.org/10.1093%2Fjxb%2Ferr307). ISSN 1460-2431 (https://search.worldcat.org/issn/1460-2431). PMID 22058404 (https://pubmed.ncbi.nlm.nih.gov/22058404).
33. Czajkowska, Beata I.; Bogaard, Amy; Charles, Michael; Jones, Glynis; Kohler-Schneider, Marianne; Mueller-Bieniek, Aldona; Brown, Terence A. (2020-11-01). "Ancient DNA typing indicates that the "new" glume wheat of early Eurasian agriculture is a cultivated member of the Triticum timopheevii group" (https://www.sciencedirect.com/science/article/pii/S0305440320301795). *Journal of Archaeological Science*. **123** 105258. Bibcode:2020JArSc.123j5258C (https://ui.adsabs.harvard.edu/abs/2020JArSc.123j5258C). doi:10.1016/j.jas.2020.105258 (https://doi.org/10.1016%2Fj.jas.2020.105258). ISSN 0305-4403 (https://search.worldcat.org/issn/0305-4403). S2CID 225168770 (https://api.semanticscholar.org/CorpusID:225168770).
34. "7.000 Jahre altes Urgetreide begeistert Experten" (https://www.br.de/nachrichten/bayern/7-000-jahre-altes-urgetreide-begeistert-experten,TfFj2yC). *BR24* (in German). 2023-05-25. Archived (https://web.archive.org/web/20230525124601/https://www.br.de/nachrichten/bayern/7-000-jahre-altes-urgetreide-begeistert-experten,TfFj2yC) from the original on 2023-05-25. Retrieved 2023-05-25.

References

Allaby, Robin G.; Peterson, Gregory W.; Merriwether, David Andrew; Fu, Yong-Bi (2005). "Evidence of the domestication history of flax (Linum usitatissimum L.) from genetic diversity of the sad2 locus". *Theoretical and Applied Genetics*. **112** (1): 58–65. doi:10.1007/s00122-005-0103-3 (https://doi.org/10.1007%2Fs00122-005-0103-3). ISSN 0040-5752 (https://search.worldcat.org/issn/0040-5752). PMID 16215731 (https://pubmed.ncbi.nlm.nih.gov/16215731). S2CID 6342499 (https://api.semanticscholar.org/CorpusID:6342499).

Arranz-Otaegui, Amaia; González Carretero, Lara; Roe, Joe; Richter, Tobias (2018). " "Founder crops" v. wild plants: Assessing the plant-based diet of the last hunter-gatherers in southwest Asia" (https://www.sciencedirect.com/science/article/pii/S0277379117306145). *Quaternary Science Reviews*. **186**: 263–283. Bibcode:2018QSRv..186..263A (https://ui.adsabs.harvard.edu/abs/2018QSRv..186..263A). doi:10.1016/j.quascirev.2018.02.011 (https://doi.org/10.1016%2Fj.quascirev.2018.02.011). ISSN 0277-3791 (https://search.worldcat.org/issn/0277-3791).

Arranz-Otaegui, Amaia (2021). "Archaeology of Plant Foods. Methods and Challenges in the Identification of Plant Consumption during the Pre-Pottery Neolithic in Southwest Asia" (https://www.brepolsonline.net/doi/10.1484/J.FOOD.5.126401). *Food and History*. **19** (1–2): 79–109. doi:10.1484/J.FOOD.5.126401 (https://doi.org/10.1484%2FJ.FOOD.5.126401). ISSN 1780-3187 (https://search.worldcat.org/issn/1780-3187). S2CID 245364458 (https://api.semanticscholar.org/CorpusID:245364458).

Banning, Edward B. (2002). "Aceramic Neolithic". In Peregrine, Peter N.; Ember, Melvin (eds.). *Encyclopedia of Prehistory, Volume 8: South and Southwest Asia*. Kluwer Academic/Plenum Publishers.

Fuller, Dorian Q.; Willcox, George; Allaby, Robin G. (2011). "Cultivation and domestication had multiple origins: arguments against the core area hypothesis for the origins of agriculture in the Near East" (https://doi.org/10.1080/00438243.2011.624747). *World Archaeology*. **43** (4): 628–652. doi:10.1080/00438243.2011.624747 (https://doi.org/10.1080%2F00438243.2011.624747). ISSN 0043-8243 (https://search.worldcat.org/issn/0043-8243). S2CID 56437102 (https://api.semanticscholar.org/CorpusID:56437102). Archived (https://web.archive.org/web/20231220080820/https://www.tandfonline.com/pb/css/t1702370357280-v1702275628000/head_4_698_en.css) from the original on 2023-12-20. Retrieved 2022-05-06.

Haas, Matthew; Schreiber, Mona; Mascher, Martin (2018). "Domestication and crop evolution of wheat and barley: Genes, genomics, and future directions" (https://doi.org/10.1111%2Fjipb.12737). *Journal of Integrative Plant Biology*. **61** (3): 204–225. doi:10.1111/jipb.12737 (https://doi.org/10.1111%2Fjipb.12737). ISSN 1672-9072 (https://search.worldcat.org/issn/1672-9072). PMID 30414305 (https://pubmed.ncbi.nlm.nih.gov/30414305). S2CID 53248430 (https://api.semanticscholar.org/CorpusID:53248430).

Kilian, B.; Ozkan, H.; Walther, A.; Kohl, J.; Dagan, T.; Salamini, F.; Martin, W. (2007). "Molecular diversity at 18 loci in 321 wild and 92 domesticate lines reveal no reduction of nucleotide diversity during Triticum monococcum (Einkorn) domestication: implications for the origin of agriculture" (https://doi.org/10.1093%2Fmolbev%2Fmsm192). *Molecular Biology and Evolution*. **24** (12): 2657–2668. doi:10.1093/molbev/msm192 (https://doi.org/10.1093%2Fmolbev%2Fmsm192). hdl:11858/00-001M-0000-0012-37D5-9 (https://hdl.handle.net/11858%2F00-001M-0000-0012-37D5-9). ISSN 0737-4038 (https://search.worldcat.org/issn/0737-4038). PMID 17898361 (https://pubmed.ncbi.nlm.nih.gov/17898361).

Kvavadze, Eliso; Bar-Yosef, Ofer; Belfer-Cohen, Anna; Boaretto, Elisabetta; Jakeli, Nino; Matskevich, Zinovi; Meshveliani, Tengiz (2009). "30,000-Year-Old Wild Flax Fibers" (https://www.science.org/doi/10.1126/science.1175404). *Science*. **325** (5946): 1359. Bibcode:2009Sci...325.1359K (https://ui.adsabs.harvard.edu/abs/2009Sci...325.1359K). doi:10.1126/science.1175404 (https://doi.org/10.1126%2Fscience.1175404). ISSN 0036-8075 (https://search.worldcat.org/issn/0036-8075). PMID 19745144 (https://pubmed.ncbi.nlm.nih.gov/19745144). S2CID 206520793 (https://api.semanticscholar.org/CorpusID:206520793). Archived (https://web.archive.org/web/20220506150806/https://www.science.org/doi/10.1126/science.1175404) from the original on 2022-05-06. Retrieved 2022-05-06.

Luo, M.-C.; Yang, Z.-L.; You, F. M.; Kawahara, T.; Waines, J. G.; Dvorak, J. (2007). "The structure of wild and domesticated emmer wheat populations, gene flow between them, and the site of emmer domestication" (https://doi.org/10.1007/s00122-006-0474-0). *Theoretical and Applied Genetics*. **114** (6): 947–959. doi:10.1007/s00122-006-0474-0 (https://doi.org/10.1007%2Fs00122-006-0474-0). ISSN 1432-2242 (https://search.worldcat.org/issn/1432-2242). PMID 17318496 (https://pubmed.ncbi.nlm.nih.gov/17318496). S2CID 36096777 (https://api.semanticscholar.org/CorpusID:36096777). Archived (https://web.archive.org/web/20231220080826/https://link.springer.com/article/10.1007/s00122-006-0474-0) from the original on 2023-12-20. Retrieved 2022-05-06.

Ozkan, H.; Brandolini, A.; Schäfer-Pregl, R.; Salamini, F. (2002). "AFLP analysis of a collection of tetraploid wheats indicates the origin of emmer and hard wheat domestication in southeast Turkey" (https://doi.org/10.1093%2Foxfordjournals.molbev.a004002). *Molecular Biology and Evolution*. **19** (10): 1797–1801. doi:10.1093/oxfordjournals.molbev.a004002 (https://doi.org/10.1093%2Foxfordjournals.molbev.a004002). ISSN 0737-4038 (https://search.worldcat.org/issn/0737-4038). PMID 12270906 (https://pubmed.ncbi.nlm.nih.gov/12270906).

Richter, Tobias; Maher, Lisa A. (2013). "Terminology, process and change: reflections on the Epipalaeolithic of South-west Asia" (https://doi.org/10.1179/0075891413Z.00000000020). *Levant*. **45** (2): 121–132. doi:10.1179/0075891413Z.00000000020 (https://doi.org/10.1179%2F0075891413Z.00000000020). ISSN 0075-8914 (https://search.worldcat.org/issn/0075-8914). S2CID 161961145 (https://api.semanticscholar.org/CorpusID:161961145).

Weiss, Ehud; Kislev, Mordechai E.; Hartmann, Anat (2006). "Autonomous Cultivation Before Domestication" (https://www.science.org/doi/10.1126/science.1127235). *Science*. **312** (5780): 1608–1610. doi:10.1126/science.1127235 (https://doi.org/10.1126%2Fscience.1127235). ISSN 0036-8075 (https://search.worldcat.org/issn/0036-8075). PMID 16778044 (https://pubmed.ncbi.nlm.nih.gov/16778044). S2CID 83125044 (https://api.semanticscholar.org/CorpusID:83125044). Archived (https://web.archive.org/web/20220510132158/https://www.science.org/doi/10.1126/science.1127235) from the original on 2022-05-10. Retrieved 2022-05-10.

Zohary, Daniel; Hopf, Maria; Weiss, Ehud (2012). *Domestication of Plants in the Old World* (4 ed.). Oxford: Oxford University Press. doi:10.1093/acprof:osobl/9780199549061.001.0001 (https://doi.org/10.1093%2Facprof%3Aosobl%2F9780199549061.001.0001). ISBN 978-0-19-954906-1.