

**MORPHOLOGY, CHEMICAL COMPOSITION, AND SEED GERMINATION
OF *HEDYSARUM POGONOCARPUM* BOISS.**

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REFERENCES

- AOAC (1984). Official methods of analysis, 14th ed. Washington DC, Association of Official Analytical Chemists: 739-740.
- BAKER H., FRANK O., DE-ANGELLS B., FEINGOLD S. (1980). Plasma tocopherol in man at various times after ingesting free or cetylaned tocopherol. *Nutrition Reports International*, 21: 531-536.
- BELL L., LLOYD D., BELL K., JOHNSON B., TEASDALE K. (2003). Seed softening in three *Hedysarum* spp. in southern Queensland. *Australian Journal of Experimental Agriculture*, 43: 1303-1310.
- BEWLEY J. D., BLACK M. (1994). *Seeds: physiology of development and germination*. Plenum Press, New York, 445 pp.
- BEWLEY J. D., BRADFORD K. J., HILHORST H. W., NONOGAKI H. (2013). *Seeds: physiology of development, germination and dormancy*, 3rd edition, Springer, New York, 392 pp.
- CHACÓN P., BUSTAMANTE R. O. (2001). The effects of seed size and pericarp on seedling recruitment and biomass in *Cryptocarya alba* (Lauraceae) under two contrasting moisture regimes. *Plant Ecology*, 152: 137-144.
- DREESEN D. R., HARRINGTON J. T. (1997). Propagation of native plants for projects in the southwestern US-Preliminary investigations. *In: Landis T. D., Thompson J. R. (Ed.) National Proceedings, Forest and Conservation Nursery Associations. General Technical Report. Portland, Oregon*, 419: 77-88.
- DUBOIS M., GILLES K. A., HAMILTON J. K. (1956). Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, 28: 350-356.
- DUNLAP J. R., BARNETT J. P. (1983). Influence of seed size on germination and early development of loblolly pine (*Pinus taeda* L.) germinants. *Canadian Journal of Forest Research*, 13: 40-44.
- DURAL H., ÇITAK B. Y. (2015). Morphology and anatomy of *Hedysarum pannosum* (Boiss.) (Fabaceae). *Acta Botanica Croatica*, 74: 19-29.
- FLORES E. M. (2002). Seed biology. *In: Vozzo J. A. (Ed.) Tropical Tree Seed Manual*. USDA Forest Service, 899 pp.
- HANLEY M. E., LAMONT B. B. (2000). Heat pretreatment and the germination of soil and canopy-stored seeds of southwestern Australian species. *Acta Oecologica*, 21: 315-321.
- HARTREE E. F. (1972). Determination of protein: A modification of the Lowry method that gives a linear photometric response. *Analytical Biochemistry*, 48: 422-427.
- HEDGE I. C. (1970). *Hedysarum* L. *In: Davis P.H. (Ed.) Flora of Turkey and the East Aegean Islands*. Vol. 3, Edinburgh University Press, Edinburgh, UK: 549-560.
- HİLOOĞLU M., SÖZEN E. (2017). Investigation of rare endemic *Verbascum alyssifolium* Boiss. in terms of soil-plant relationship. *Anadolu Üniversitesi Bilim ve Teknoloji Dergisi*, 6: 14-21 (in Turkish).
- HOWITT C. A., POGSON B. J. (2006). Carotenoid accumulation and function in seeds and non-green tissues. *Plant, Cell & Environment*, 29: 435-445.
- HU X. W., WANG Y. R., WU Y. P. (2009). Effects of the pericarp on imbibition, seed germination, and seedling establishment in seeds of *Hedysarum scoparium* Fisch. et Mey. *Ecological Research*, 24: 559-564.
- ISTA (International Seed Testing Association) (2009). *International rules for seed testing* Bassersdorf, Switzerland, 290 pp.
- KOSTER K. L., LEOPOLD A. C. (1988). Sugars and desiccation tolerance in seeds. *Plant Physiology*, 88: 829-832.
- LARSON L. A., BEEVERS H. (1965). Amino acid metabolism in young pea seedlings. *Plant Physiology*, 40: 424-432.
- LEISHMAN M. R., WRIGHT I. J., MOLES A. T., WESTOBY M. (2000). The evolutionary ecology of seed size. *In: Fenner M. (Ed.) Seeds: the Ecology of Regeneration in Plant Communities*, 31-57.
- MIERZIAK J., KOSTYN K., KULMA A. (2014). Flavonoids as important molecules of plant interactions with the environment. *Molecules* 19: 16240-16265.
- PRIESTLEY D. A. (1986). *Seed aging: implications for seed storage and persistence in the soil*. Ithaca, New York, 304 pp.
- REDENTE E. F. (1982). Sweet vetch seed germination. *Journal of Range Management*, 35: 469-472.
- SAS (1985). *SAS Introductory Guide*, 3rd edition, NC, USA, 99 pp.
- SAKANAKA S., TACHIBANA Y., OKADA Y. (2005). Preparation and antioxidant properties of extracts of Japanese persimmon leaf tea (kakinoha-cha). *Food Chemistry*, 89: 569-575.
- SCHMIDT L. (2000). *Guide to handling of tropical and subtropical forest seed*. Danida Forest Seed Centre, Denmark, 532 pp.
- SMITH M. T., WANG B. S. P., MSANGA H. P. (2002). Dormancy and germination. *In: Vozzo J. A. (Ed.) Tropical tree seed manual. Agriculture Handbook*, 721: 149-176.

- SOMOGYI M. (1952). Notes on sugar determination. *Journal of Biological Chemistry*, 195: 19-23.
- SORIANO D., OROZCOSEGOVIA A., MÁRQUEZGUZMÁN J., KITAJIMA K., BUEN A. G., HUANTE P. (2011). Seed reserve composition in 19 tree species of a tropical deciduous forest in Mexico and its relationship to seed germination and seedling growth. *Annals of Botany*, 107: 939-951.
- SULAS L., RE G. A., CAREDDA S. (1996). Hard seed breakdown pattern of sulla (*Hedysarum coronarium* L.) in relation to its regeneration capacity and persistence. *Options Méditerranéennes*, 39: 79-82.
- TANG A. J., TIAN M. H., LONG C. L. (2010). Dormancy and germination in short-lived *Lepidium perfoliatum* L. (Brassicaceae) seeds. *Pakistan Journal of Botany*, 42: 201-211.
- TAYLOR G. B., EWING M. A. (1992). Long-term patterns of seed softening in some annual pasture legumes in a low rainfall environment. *Australian Journal of Experimental Agriculture*, 36: 331-337.
- TONGUÇ M., ELKOYUNU R., ERBAŞ S., KARAKURT Y. (2012). Changes in seed reserve composition during germination and initial seedling development of safflower (*Carthamus tinctorius* L.). *Turkish Journal Biology*, 36: 107-112.
- VERA M. L. (1997). Effects of altitude and seed size on germination and seedling survival of land plants in north Spain. *Plant Ecology*, 133: 101-106.
- VIDIGAL D. S., MARQUES A. C. S., WILLEMS L. A. J., MÉNDEZ-VIGO B., HILHORST H. W. M., BENTSINK L., XAVIER PICÓ F., ALONSO-BLANCO C. (2016). Altitudinal and climatic associations of seed dormancy and flowering traits evidence adaptation of annual life cycle timing in *Arabidopsis thaliana*. *Plant, Cell and Environment*, 39: 1737-1748.
- WILLAN R. L. (1985). A guide to forest seed handling. FAO Forestry Paper 20/2. FAO Rome, 379 pp.
- XIAO W. H., YAN R. W., YAN P. W. (2009). Effects of the pericarp on imbibition, seed germination, and seedling establishment in seed of *Hedysarum scoparium* Fisch. et Mey. *Ecological Research*, 24: 559-564.
- YILMAZ M. (2006). The method of naked stratification at controlled moisture content in breaking seed dormancy. *Journal of the Faculty of Forestry*, 56: 135-145.
- YILMAZ M., TONGUÇ F. (2009). Fruit and seed size variability of *Fraxinus ornus* subsp. *cilicica*. *International Journal of Natural and Engineering Sciences*, 3: 133-136.
- ZENG Y. J., WANG Y. R., BAO P., TA, L. T., SU L. D. (2005). Study on the effects of soil temperature, soil moisture content, sowing depth, and sand cover on seed germination and seedling growth of *Reaumuria soongorica* and *Zygophyllum xanthoxylum*. *Acta Prataculturae Sinica*, 14: 24-31.
- ZHAO L. L., MO B. T., WANG P. C., ZHANG Y., LONG Z. F. (2015). Relationship of *Sophora davidii* seed size to germination, dormancy, and mortality under water stress. *South African Journal of Botany*, 99: 12-16.
- ZHAO M., ZHANG H., YAN H., QIU L., BASKIN C. C. (2018). Mobilization and role of starch, protein, and fat reserves during seed germination of six wild grassland species. *Frontiers in Plant Science*, 9, 234, 11 pp.