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Review

The invasive status of wild barley (*Hordeum spontaneum* Koch) in Iranian flora

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The success of a weed's biological pathway is dependent on several factors including the mechanism(s) of dispersal, longevity of seeds in the soil seed bank, adaptation to varying environmental conditions and, competitive and reproductive abilities. In Near East barley, some races can be identified as wild but in other races wild and weed forms are confounded. Wild barley has wider distribution than the wild wheat and is spread over a wide area in the East Mediterranean basin and West Asiatic countries. In the Fertile Crescent countries, *Hordeum spontaneum* occupies a whole array of secondary man-made habitats. Invasive weeds possess a variety of characteristics that enable them to disperse rapidly into new areas. A variety of both aboveground and belowground plant traits can be used for identifying invasive species. Wild barley has some considerable traits including high genetic variation, high allelopathic potential, high relative growth rate, root characteristics, high competitive abilities and, became an invasive species in many habitats of Iran. Further studies are essential to evaluate the other mechanism(s) of invasiveness of wild barley in alien environment.

Key words: Wild barley, *Hordeum spontaneum*, habitat, distribution, invasive weed.

INTRODUCTION

As a result of the importance of weeds to agriculture and their probable roles in plant domestication, definition of weed is important. Some of the current definitions used in agronomic instruction, such as "a weed is a plant that does more harm than good", are clearly inadequate. A weed is much more than that, but, the implications of the term have changed over the years (Harlan, 1975). Harlan and de Wet (1965) defined weed as "a generally unwanted organism that thrive in habitats disturbed by man". Man has probably always caused some disturbance of habitats. Before he knew how to manipulate fire, man's disturbances were probably very minor and more or less limited to the vicinity of cave or camp. After he began to use the fire deliberately after the vegetation, his disturbances were more widespread and more intense. Still, his set fires were relatively causal compared to the habitats he created after developing an effective agriculture in which whole landscapes were churned up and entire floras destroyed and replaced by new vegetation. The species adapted to the new, artificial habitats are mostly crops or weeds. Because both are adapted to the same habitats, however, practices that tend to favor crops also tend to favor weeds.

Some crops undoubtedly originated from weed progenitors and some crops have degenerated into weed races. The evolution of weeds often parallels the evolution of crops and the same principles apply to both. Both weeds and crops often begin with a common progenitor, as in those complexes where each crop has a companion weed. There are weed and cultivated races of wheat, barley, sorghum, rice, oats, pearl millet, potato, tomato, pepper, sunflower, carrot, radish, lettuce, and many others (Klingman and Ashton, 1982). In Near Eastern barley, some races can be identified as wild, but in other races wild and weed forms are confounded. There is a small wadi race that appear to be truly wild. In more mesophytic races of barley, however, it is difficult to distinguish the weed from the wild (Harlan,1975).

Effects of seed dormancy on longevity of weed seeds

Seed dormancy, a major adaptive trait in plants facilitates the survival of weeds and provides resistance to preharvest sprouting in members of Poaceae family. Most weeds are able to germinate throughout the growing season and that is an important reason why they are successful, though each individual will experience different success (Gutterman and Nevo, 1993). Seeds exhibiting dormancy usually have to experience periods of favorable environmental conditions during a period called “after-ripening”. After-ripening is a process whereby seeds are gradually able to germinate over a broad range of conditions (Baskin and Baskin, 1987). Hamidi et al. (2011a) showed that the major factor of seed dormancy in *Hordeum spontaneum* is glumellae. In fact, glumellae have either physical or chemical effects on the germination of caryopses and finally, on the longevity of this species in the soil seed bank.

H. spontaneum* as an ancestor of *H. vulgare

It is clear now that only a single genuinely wild species of barley is closely related to the various cultivated barley forms, and should be regarded as their sole ancestor. This is two-row brittle *H. spontaneum*. This plant has the same chromosome number as cultivated barley, *H. vulgare*. Both are diploid (2n = 14), hybrids between them are fully fertile and show regular pairing in meiosis. From a genetic point of view, *H. spontaneum* and various forms of cultivated barley did not diverge to the extent of representing fully independent, separated species (Harlan, 1966).

***H. spontaneum* distribution**

Wild barley shows wider distribution than the wild wheats. It is spread over a wide area in the East Mediterranean basin and West Asiatic countries, penetrating east as far as Turkmenia and Afghanistan. Wild barley occupies, at present, both primary and segetal, man-made habitats. Its distribution center lies in the Fertile Crescent Belt, that is, in a wide arc, stating from Palestine and Transjordan in the south-west, stretching north towards South Turkey, and bending south-east towards Iraqi Kurdestan and South-west Iran. In this general area, and only here, *H. spontaneum* is massively and continuously spread over primary habitats. It constitutes an important annual component of open formations, and is particularly common in the summer-dry belt of the deciduous oak park forest, east, north and west of the Syrian desert and the Euphrates basin, and the slope facing the Jordan rift valley.

From here, wild barley spills over the drier and warmer deserts. In the Fertile Crescent countries, *H. spontaneum* also occupies a whole array of secondary man-made habitats, that is, opened-up Mediterranean maquis, abandoned cultivation, edges of fields and roadsides. Further west (Aegean region and Cyrenaica) and further east (North-east Iran, Central Asia and Afghanistan), *H. spontaneum* is rare and much more sporadic in its distribution, it rarely builds even local masses and seems to be completely restricted to segetal habitats or to sites which have been drastically churned by man's activity. Thus, in these peripheral areas, wild barley does not seem to be genuinely wild. As in the case of wild einkorn, it apparently spread to these locations as a weed, as a consequence of agricultural activity (Harlan, 1966). In general, wild barley does not tolerate extreme cold and it is only occasionally found above 1500 m. It is thus almost completely absent from the elevated continental plateaus of Turkey and Iran.

On the other hand, it is somewhat more xeric as compared with the wild wheat and penetrates relatively deep into warm steppes and deserts. Morphologically too, *H. spontaneum* is quite variable and several distinct races can be distinguished. Robust types with extremely large seeds and extraordinarily long awns occur in the catchment area of Upper Jordan Valley, often in close association with similarly robust *Triticum dicoccoides* form (Harlan, 1966). A much more slender desert type is found in the drier steppes and in desert dry water courses. This race is sporadically spread from the Negev to the steppic plateaux of Transjordan, northward to the Turkish border, and eastward to Iran and Afghanistan. It is a small, grassy type with kernels only half size of the robust races of the Eastern Galille.

All intermediate types between these extremes are widely spread in Palestine, Syria, Turkey and Iran (Harlan, 1966). Although the natural stands of *H. spontaneum* have been considered a natural part of the rich grass cover of open-woodland *Quercus brantii* belt in Zagros of Iran (Harlan, 1975), but recently, the species population densities have been increased in many other parts of our country and then may be considered as an invasive weed.

Characteristics of invasive species

Invasive weeds possess a variety of characteristics that enable them to disperse rapidly into new areas and out-compete crops and native or desirable non-native vegetation for light, water, nutrients, and space (Westbrooks, 2001). The success of a weed's biological pathway is dependent on several factors including the method or mechanism of dispersal, longevity of propagule, adaptiveness to varying environmental conditions, and competitive and reproductive ability.

Botanists, ecologists, and weed scientists have long been aware of the problem of establishment of non-native weed species and have gleaned knowledge of how some species reproduce, spread, and interact with crops and native and acceptable non-native species. To prevent economic and ecological diversity losses, it is necessary to prevent additional introductions and invasions of plant species that have the potential to become serious pests of agriculture, forest urban, and native areas. Understanding the basic biology and ecology of weeds is important to determine pathways of entry, spread, establishment, and persistence. Biology of pathways varies depending on the species and environmental surroundings.

Biological processes and characteristics that are most important for weeds to thrive are dependent on reproduction, dispersal, phenology, physiology, protection, habitat requirements, tolerances to environmental stress, and interspecific interactions (Brayson and Carter, 2004). Invader species affect the distribution, abundance, reproduction, and evolution of many native species (Sala et al., 1999). Humans are often directly or indirectly responsible for most introductions, whether intentional or unintentional, but animals and natural processes also disperse plants (Reed, 1977). The most common pathways of movement associated with humankind include contaminated soil, food, feed, fiber, ballast, and packing and bagging material. However, pathways for introduction and spread may be from ornamentals, forages, or plants used for erosion control that were once thought to be acceptable but have become weedy. Natural processes including wind, hurricanes, tornadoes, earthquakes, and floods are also responsible for plant dispersal but to a lesser extent than human activities (Brayson and Carter, 2004).

Natural barriers and restricted migration routes prevent many plant propagules from dispersing over great distances; however, the current speed and ease of world transportation by humans and their cargo has increased the rate and distance of dispersal of plant propagules. After introduction, a plant species may remain near the point of introduction without becoming a pest or the plant may continue dispersing from the initial point of entry. Unfortunately, newly introduced weeds are often unnoticed until after their numbers and range increase greatly. The period of time between introduction and invasion is termed the lag phase (Radosevich and Holt, 1984). Invasive species have an ability to undergo genetic changes due to selection pressure imposed by the alien environment and exhibit quick response anthropogenic disturbances (Sakai et al., 2001).

Factors affecting the invasiveness of *H. spontaneum*

A variety of both aboveground and belowground plant traits can be used for identification of invasive species. Ehrenfeld (2004) accounted for some specific traits for invasive species including genetic variation, high allelopathic potential, high growth rate (measured as relative growth rate), high live tissue and litter nutrient contents, especially nitrogen, and root system size or morphology that contrasts strongly with native species. Based on Ehrenfeld's pointing out, wild barley has some considerable traits including high genetic variation (Brown et al., 1978; Nevo et al., 1986; Volis and Mendlinger, 1998; Volis et al., 2002b), high allelopathic potential (Hanson et al., 1981; Hanson et al., 1983; Barria et al., 1991; liu and Lovett, 1993; Liu et al., 2005; Hamidi et al., 2008a; Hamidi et al., 2008b; Hamidi et al., 2010b) high relative growth rate (Elberse et al., 2003; Poorter et al., 2005; Van Rijin et al., 2000), root characteristics (Ceccarelli et al., 1998; Invandic et al., 2000; Volis et al., 2001; Volis et al., 2002a; Volis et al., 2004), high competitive abilities (Hamidi et al., 2010a; Hamidi et al., 2011c; Hamidi et al., 2011b), the lack of effective herbicides caused increase in its resistance to used herbicides and consequently, changing in the flora and dominance of weeds that were not in the range of herbicides control, high tolerance to osmotic stress by reducing the cellular osmotic potential as a consequence of a net increase in solute accumulation and then, better uptake of water and nutrients from the soil under stress conditions (Matsuda and Riazi, 1981), sooner maturation than wheat in all climates of Iran, and then, can be an invasive species. Further, studies are thus essential to evaluate the other mechanism(s) of invasiveness of wild barley in alien environment especially regarding its colonization, expansion, establishment, and ecological impact as to take timely action for its management.

REFERENCES

Barria BN, Copaja SV, Niemeyer HM (1991). Occurrence of DIBOA in wild *Hordeum* species and its relation to aphid resistance. Phytochemistry, 31: 89-91.

Baskin JM, Baskin CC (1987). Temperature requirements for after-ripening in buried seeds of four summer annual weeds. Weed Res., 27: 385-388.

Brayson CT, Carter R (2004). Biology of pathway for invasive weeds. Weed Technol., 18: 1216-1220.

Brown AH, Nevo DE, Zohary D, Dagan O (1978). Genetic variation in natural population of wild barley (*Hordeum spontaneum*). Genetica, 49: 97-108.

Ceccarelli S, Grando G, Impiglia A (1998). Choices of selection strategy in breeding barley for strees environments. Euphytica, 103: 307-318.

Ehrenfeld JG (2004). Implications of invasive species for belowground community and nutrient processes. Weed Technol., 18: 1232-1235.

Elberse IAM, Van Damme JMM, Van Tienderen PH (2003). Plasticity of growth characteristics in wild barley (*Hordeum spontaneum* Koch) in response to nutrient limitation. J. Ecol., 91: 371-382.

Gutterman Y, Nevo E (1993). Germination comparison study of *Hordeum spontaneum* regionally and locally in Israel: A population in the Negev Desert Highlands and from two opposing slopes on Mediterranean Mount Carmel. Barley Genetics Newsletter, 22: 65-

71.
Hamidi R, Mazaheri D, Rahimian H, Alizadeh HM, Ghadiri H, Zeinaly H (2008a). Phytotoxicity effects of soil amended residues of wild barley (*Hordeum spontaneum* Koch) on growth and yield of wheat (*Triticum aestivum*). Desert, 13: 1-7.
Hamidi R, Mazaheri D, Rahimian H, Alizadeh HM, Ghadiri H, Zeinali H (2008b). Inhibitory effects of wild barley (*Hordeum spontaneum* Koch) residues on germination and seedling growth of wheat and its own plant. Desert, 11: 35-43.
Hamidi R, Mazaheri D, Rahimian H (2010a). Effects of nitrogen on *Hordeum spontaneum* (Koch) competition with winter wheat. Aust. J. Basic Apll. Sci., 4: 4695-4700.
Hamidi R, Mazaheri D, Rahimian R (2010b). Effect of wild barley (*Hordeum spontaneum* Koch) leaf and culm extracts on seed germination and seedling growth of winter wheat (*Triticum aestivum* L.). Iranian J. Weed Res., 2: 19-28.
Hamidi R, Mazaheri D, Rahimian R (2010c). Winter wheat nitrogen yields as affected by wild barley population densities and nitrogen. Aust. J. Basic Appl. Sci., pp. 4726- 4739.
Hamidi R, Mazaheri D, Rahimian R (2011a). Wild barley (*Hordeum spontaneum* Koch) seed germination as affected by dry storage periods, temperature regimes, and glumellae characteristics. Iranian J. Weed Sci., 15: (in press).
Hamidi R, Mazaheri D, Rahimian R (2011b) Wild barley (*Hordeum spontaneum* Koch) and winter wheat (*Triticum aestivum* L.) growth responses to nitrogen and population densities in a replacement series study. Can. J. Scient. Indust. Res., 2: 251-267.
Hanson AD, Traynor PL, Dits KM, Reicosky DA (1981). Gramine in barley forage – Effects of genotype and environment. Crop Sci., 21: 726 – 730.
Hanson AD, Dits KM, Singletary GW, Leland TJ (1983). Gramine accumulation in leaves of barley grown under high temperature stress. Plant Physiol., 71: 896 – 904.
Harlan JR (1966). Distributions of wild wheat and barley. Science, 153: 1074 - 1080.
Harlan JR (1975). Crops and Man. American Society of Agronomy, Crop Science Society of America, Madison, WI., p. 295.
Harlan JR, de Wet JMJ (1965). Some thought about weeds. Econ. Bot., 19: 16-24.
Invandic VC, Hackett A, Zhang AZ, Staub JE, Nevo E, Thomas WTB, Forster BP (2000). Phenotypic responses of wild barley to experimentally imposed water stress. J. Exp. Bot., 51: 2021-2029.
Klingman GC, Ashton FM (1982). Weed Science: Principles and Practices, 2nd edition. John Wiley and Sons, Inc. New York, p. 449.
Liu DW, Lovett JV (1993). Biologically active secondary metabolites of barley. I. Developing techniques and assessing allelopathy in barley. J. Chem. Ecol., 19: 2217-2230.
Liu DL, An M, Jhonson IR, Lovett JV (2005). Mathematical modeling of allelopathy: IV. Assessment of contributions of competition and allelopathy to interference by barley. Nonlinearity in Biology, Toxicology, Medicine, 3: 213-224.
Matsuda K, Riazi A (1981). Stress-induced osmotic adjustment in growing regions of barley leaves. Plant Physiol., 68: 571-576.
Nevo E, Kaplan D, Storch N, Zohary D (1986). Genetic diversity and environmental associations of wild barley, *Hordeum spontaneum* (Poaceae), in Iran. Plant Syst. Ecol., 153: 141-164.
Poorter H, van Rijin CP, Van Hola TK, Verhoeven KJF, de Jong YEM, Stam P, Lambers H (2005). A genetic analysis of relative growth rates and underlying components in *Hordeum spontaneum*. Oecologia, 142: 360- 377.
Radosevich SR, Holt JS (1984). Weed Ecology. John Wiley Publishing Co., p. 265.
Reed CF (1977). Economically Importance Foreign Weeds. Agriculture Handbook No. 498. Washington, DC: United States Department of Agriculture, p. 746 .
Sakai AK, Allendorf FW, Holt JS (2001). The population biology of invasive species. Ann. Rev. Ecol. Syst., 32: 305-332.
Sala OE, Chapin FS, Gardner RH, Lauenroth WK, Mooney HA, Ramakrishnan PS (1999). Global change, biodiversity and ecological complexity. In: The Terrestrial Biosphere and Global Change: Implications for Natural and Managed Ecosystems (Eds Walker B, Steffen W, Canadell J, Ingram J). Cambridge University Press, Cambridge, UK, pp. 304-328.
Van Rijin CPE, Heersche I, Van Berkel YEM, Nevo E, Lambers H, Poorter H (2000). Growth characteristics in *Hordeum spontaneum* populations from different habitats. New Phytologist, 146: 471-481.
Volis S, Mendlinger S (1998). Phenotypic variation and stress resistance in core and peripheral populations of *Hordeum spontaneum*. Biodiversity Conservation, 7: 799-813.
Volis S, Yakubov B, Shulgina I , Ward D, Zur V, Mendlinger S (2001). Tests for adaptive RAPD variation in population genetic structure of wild barley, *Hordeum spontaneum* Koch. Biological J. Linn. Soc., 74: 298 – 303.
Volis S, Mendlinger S, Ward D (2002a). Adaptive traits of wild barley plants of Mediterranean and desert origin. Oecologia, 133: 131 – 138.
Volis S, Mendlinger M, Ward D (2002b). Differentiation in populations of *Hordeum spontaneum* Koch along a gradient of environmental productivity and predictability: Plasticity in response to water and nutrient stress. Biol. J. Linn. Soc., 75: 301-312.
Volis S, Mendlinger M, Ward D (2004). Differentiation in populations of *Hordeum spontaneum* Koch along a gradient of environmental productivity and predictability: Intra-and interspecific competitive responses. Isr. J. Plant Sci., 52: 223-234.
Westbrooks RG (2001). Invasive species, coming to America: New strategies for biological protection through prescreening, early warning, and rapid response. Wild Land Weeds, 4: 5-11.