Journal of Crop and Weed, 13(3): 204-208 (2017)

Weed and water management in fenugreek (*Trigonella foenum graecum* L.)- a review

PEMBA H. BHUTIA, N.CHATTOPADHYAY, J. K. HORE, [1]R.YONZONE AND [2]R. LEPCHA

Department of Spices and Plantation Crops, [2]Department of Soil and Water Conservation, Bidhan Chandra Krishi Viswavidyalaya,Mohanpur-741252, Nadia, West Bengal
[1]Department of Plant Pathology, College of Agriculture),UBKV, Majhian, Dakshin Dinajpur,West Bengal

Received :15-08-2017 ; Revised : 21-11-2017 ; Accepted : 30-11-2017

ABSTRACT

Fenugreek (Trigonella foenum graecum) is a legume using as a spice throughout the world to enhance the sensory quality of foods. It is slow growing crop during its initial stage and getting severe competition from the weeds. Therefore, different methods of weed management like prevention, eradication, cultural, mechanical, and chemicals are followed in fenugreek. s . Different methods of irrigation practiced in fenugreek cultivation are surface irrigation, drip irrigation and sprinkler irrigation. Therefore, the review article deals with some important results of weed and water management in fenugreek in achieving better growth and yield..

Keywords : Fenugreek, growth, water, weed, yield

Fenugreek (*Trigonella foenum graecum* L.) is an important spice, occupying third and fourth place in area and production among all the minor spices grown in India. It is an annual, small seeded crop with yellowish brown colour. Seeds are a rich source of proteins, minerals, vitamins A and C. India is one of the major producers of fenugreek, with annual export of nearly 1500 tonnes. The area and production of fenugreek in India was 90,500 ha and 1,10,530 t respectively, during 2013-14 (Spice Board, 2014). Fenugreek is raised in *rabi* season and fairly tolerant to frost and low temperature. The seeds are hot, with a sharp bitter taste, tonic, antipyretic, anthelmentic, increase the appetite, astringent to the bowels, cure leprosy, vomiting, bronchitis, piles; remove bad taste from the mouth, useful in heart disease (Aggarwal and Shishodia, 2006). Both leaves and seeds are extensively used for medicinal purposes like chronic dysentery, diarrhoea, chronic cough, dropsy, spleen, diabetes, colic troubles, ulcers and rickets (Pruthi, 1979). Furthermore, it stabilizes the insulin, blood sugar and hemoglobin levels. Fenugreek also to be used as antidiabetic remedy for both type I and II diabetes. Saponins and diosgenin present in fenugreek are responsible for hypolipidemic and anti-diabetic action (Ahmadiani *et al.*, 2001. Talpur *et al.*, 2005) .Fenugreek is described as an antihyperglycemic herb in humans and laboratory animal (Gopalan *et al.*, 1998, Kaviarasan *et al*., 2007). It can be grown in all types of soil under irrigated conditions, but does best on loamy soils. Fenugreek is slow growing crop during its initial stage and getting severe competition from the weeds. Weeds are an important constraint in agricultural production systems, acting at same tropic level as the crop; weeds capture a part of the available resources that are essential for plant growth (Oerke, 2006; Ryan *et al*., 2009; Smith *et al*., 2010). Inevitably, leaving weeds uncontrolled will sooner or later lead to considerable reductions in crop yield and increase production cost. Mention one or two update references in respect to the level of yield loss in fenugreek due to weed. Manual weed control is labour intensive and therefore limits the production area (Verma *et al*., 2008; Dubey, 2014). If unchecked, it may reduce the seed yield to the tune of 14.2 to 69.0 per cent depending upon their density and duration of competition (Tripathi and Singh, 1993). The seed is mainly used as condiment and in the pharmaceutical industry especially in preparation of ayurvedic medicines, while young plants are used as a vegetable and forage. At the global level the food loss due to weeds is reported to be about 287 million tonnes accounting for 11.5 per cent of the total food production.

Weed management practices in fenugreek

Weed management in the present agriculture is most important crop protection practice to increase the global food production. It can be defined as 'To create an atmosphere in the crop zone so that the crop gets favourable situation for its growth and development by minimizing the population of competitive weed plants. The major problem creates by the weed seeds. (more than 3 million populations m^{-2} within 0-15 cm soil depth). Thus, to manage weed plants it is necessary to plan for an annum (crop sequence) instead of restricting to manage the weeds only in crop fields when it comes out (population average 1000 m^{-2}). The crop – weed competition for major resources like nutrients, water, space and light revealed that weeds are dominant because of their more sustainable nature. The weed management

Email: hissaybhutia83@gmail.com

has two important phases; pre-infested (weed prevention including quarantine law) and post infested which includes weed control and weed eradication methods.

Some common weeds found in fenugreek are listed below:

Monocots - Bermudagrass (*Cynodon dactylon* L.), nut sedge (*Cyperus rotundus* L.), wild onion (*Asphodelus tenuifolius*). **Dicots -** Sweet clover (*Melilotus alba*), clover (*Melilotus indica* L.), pimperne (*Anagallis arvensi* L.), morning glory (*Convolvulus arvensis* L.), golden duck (*Rumax dentatus* L.), lamb squarters (*Chenopodium album* L.), goose foot (*Chenopodium murale* L.),

Weed management mostly includes prevention, eradication and control by regulated use, restricting invasion, suppression of growth, prevention of seed production and complete destruction. The effectiveness of any weed management programme depends largely on timeliness of the control. Preventive, cultural, mechanical, and chemical weed management methods all are most effective if applied at the correct time. Fields that are kept free of weeds for the first several weeks after planting give the crop a competitive edge that allows the crop to shade out or out compete weeds that emerge later in the season. This strategy can be implemented through improvements in application technology (Brown *et al*., 2007), the use of factor adjusted dosages and patch spraying, which enhances efficiency of herbicides and save time (Gerhards and Christensen, 2003). A second strategy is to focus more on alternative curative control technologies, like cultural, biological and mechanical weed control (Singh and Singh, 2006; Das *et al*., 2012). Preventive and cultural control can be described as any adjustment or modification to the general management of the crop or cropping systems that contributes to the regulation of weed populations and reduces the negative impact of weeds on crop (Dubey, 2014)

Preventive methods are used to stop the spread of weeds. Preventing the introduction of weeds is usually easier than controlling them after establishment. In general, spread of weeds within country can be reduced by clean seed laws, cleaning farm equipment and produce, cleaning irrigation water, cleaning sand and gravel and reducing the number of weed seeds returned to the soil (Das, 2008). Introduction of weed in crop field can be prevented by using weed free seed, not using fresh or partially decomposed FYM or compost, proper cleaning of farm machinery before sowing and keeping farm bund and irrigation/drainage channel free from weeds (Verma and Singh, 2008).

Eradication is a complete removal of all live plant parts and seeds of the weed from an area. In general, eradication of common weed seeds is not practiced as these weeds harbor crop pests or secretes soil nematidicides. They may be useful to hold the soil nutrients against leaching losses during fallow period. However weed eradication is justified against weeds like *Striga, Cuscuta, Lantana* to prevent their dispersal to new areas of useful land and water bodies . Weed eradication programme should begin when the weed growth is limited. If the weed occupied large and continuous areas eradication is not economical. It should be carried out more than one year. It requires intensive initial efforts to destroy all plant parts and followed by many years of vigilance to prevent the new weed seedlings from establishing into adult plants.

Cultural and crop management techniques provide a healthy crop to compete with weeds. Crop competition can be an inexpensive and effective aid to weed management if used to its fullest advantage. Cultural methods provide competitive advantage to crop against weeds by reducing weed establishment (Singh, 2014), and through selective stimulation, facilitating faster crop growth to smother weeds (Das *et al*., 2012). Globally, cultural control has been one of the most widely used control options and includes stale seedbed techniques, crop rotation, increase the competitive ability of the crop, time of seeding and irrigation, inclusion of cover crops, and intercropping (Kumar, 2014), conscious use of crop interference, use of cropping pattern, and tillage systems (Zimdhal, 2007); employing time, method, rate of sowing, rate of fertilizer, inter and mixed cropping, tolerance cultivars and spacing (Verma and Singh, 2008); smother crop, summer ploughing or following (Dubey, 2014) have carried out for successful weed management Examples of cultural techniques includes; selecting the best crop varieties; crop populations at the proper timing; scouting fields regularly for weeds, insects, and diseases and controlling them when necessary; and including crop rotations in the system. Composting, ensiling, or feeding weeds or weed-infested crops to livestock can destroy the viability of weed seeds.

Biological weed control involves the use of other living organisms, such as insects, diseases, or livestock, for the management of certain weeds. In theory, biological control is well suited for an integrated weed management program. However, the limitations of biological control are that it is a long term under taking, its effects are neither immediate nor always adequate, only certain weeds are potential candidates and the rate of failure for past biological control efforts has been fairly high. There have been a few success stories of weed species being managed with insect or disease biocontrol agents. (Haque and Ghaffer, 1992) reported that the *Trichoderma viride, T. hamatum* and *Rhizobium meliloti* used as seed dressing and or as soil drench reduce *Macrophomina phaseolina* infection by more than 50 per cent on 30 day old fenugreek seedlings. *T. harzianum, T. hamatum, T. pseudokoingii* and *R. meliloti* are used either as seed dressing and or as soil drench completely controlled the infection of *Rhizobium solani* both on 30 and 60 days old plants. Herbivores such as sheep and

goats can provide successful control of some common pasture weeds. Weeds are managed either manually or by using herbicides but for the former is costly, time consuming and regenerates soon and thus not feasible and later on creates soil and water pollution, forces heavy financial burden and needs technical know-how for its application. To overcome these problems, biological control appears pollution free and economic option for weeds control. Insects, mites, nematodes, plant pathogens, animals, fish, birds and their toxic products are major weed controlling biotic agents and among these insects are one of the important groups (Tiwari *et al*., 2013; Kumar, 2014).

Chemical herbicides provide a convenient, economical and effective way to help manage weeds. Many factors determine when, where, and how a particular herbicide can be used most effectively. Understanding some of these factors enables us to use herbicides to their maximum advantage. Fenugreek irrigated at 1.0 IW/CPE ratio along with pendimethalin @ 0.75 kg ha^{-1} pre-emergence + IC at 40 DAS is best to get maximum yield and maximum seeds yield (Mehta *et al*., 2010). The application of fenugreek with fluchloralin at 0.75 and 1.25 kg ha^{-1}; pre emergence applications of oxyfluorfen at 0.15 and 1.0 kg ha^{-1}, and pendimethalin at 1.0 and 1.5 kg ha^{-1}combination of the lowest herbicide rate and hand weeding at 50 days after sowing (DAS); hand weeding at 25 DAS, hand weeding at 25 and 50 DAS can control the effectively. (Chaudhary, 1999). The application of pendimethalin in fenugreek @ 1.0 kg ha^{-1} + hand weeding at 25 DAS reduced the weed population (Kamboj *et al*., 2004)**.** Minimum weed count and dry weight of weeds were also noticed in Chrysanthemum by application of pendimethalin@1kg.a.i.ha^{-1} in tarai condition of Uttrakhand (Kumar *et al*.,2017).

Hand weeding

Sharma, 2009 revealed that two hand weedings at 20 and 40 DAS recorded minimum dry weight of both monocot and dicot weeds with the highest weed control efficiency (63.0%). Chovatia *et al*., 2009 also reported that weed density and weed dry weight was significantly lowest under two hand weeding *i.e.* at 20 and 45 DAS. Weed free treatment by pre-emergence application of oxadiargyl @ 75 g ha^{-1} +1 hand weeding at 45 days after sowing but highest B: C ratio (4.38) was recorded with pre-emergence application of oxadiargyl @ 75 g ha^{-1} +1 hand weeding at 45 DAS (Meena, *et al.*,2013).

Mulching

Mulching is one of the possible ways to control weeds without using herbicides (Verma and Singh, 2008; Awasthy *et al*., 2014).

Water management in fenugreek

Bhutia and Sharangi (2016) studied on fenugreek different sowing dates : 2nd, 9th, 16th and 23rd and 30th November and soil moisture content at different soil depths where as 2nd November and irrigation should be given in all the major growth phases at seedling, branching, flowering, pod formation and pod development stages gives the highest seeds yield.

Important factors influencing water management

Nature of crop based on water requirement

Irrigation must start immediately after sowing to help in seed germination and continued when necessary. This early watering is necessary even for not irrigated fenugreek crops, if rain is not expected after sowing. (Fazli and Hardmanithin, 1968 and Duke, 1986). Watering supplied should be at a depth that is within which of the root. As fenugreek possesses a shallow root system, heavy watering is not needed. The determination of soil moisture and inspection of plant appearance, preferable, in the morning are going to help the grower to decide a suitable time to apply irrigation. It is estimated that a water quantity of 200 m^3 ha^{-1} every time for sandy soils, and 250 m^3 ha^{-1} for heavier soils replicated every fortnight is sufficient for successful fenugreek crops. (Pareek and Gupta, 1981) reported the application of irrigation 5 times for the whole growing of a fenugreek crop under Indian conditions.

Nature of soil based on water requirement

Drip irrigation

The drip irrigation is the most competent, especially in vegetables, orchard crops, flowers and plantation crops (Mamata Swain, 1999). Drip irrigation is a very high water application efficiency of about 90-95 per cent. Yadav *et al*.(2013) reported that maximum seed yield (15.98 q ha^{-1}) and water use efficiency were observed under drip irrigation as compared with recommended surface irrigation (13.02 q ha^{-1}).

Sprinkler Irrigation

The sprinkler irrigation system is effective for irrigation on uneven lands where land shaping is expensive or technically not practicable and on shallow soils. Daspute *et al*., 2011 reported that irrigation through mini sprinkler at 0.8 IW/CPE ratio recorded significantly higher growth and yield attributes, seed and straw yield (1994 and 3488 kg ha^{-1}, respectively) as compared to 0.6 IW/CPE ratios.

In conclusion, both weed and water management is important for getting proper growth and yield of fenugreek. If they are not managed in proper and systematic way, their impact can lead directly and indirectly in the performance of crops causing huge losses in production and productivity. Therefore a good knowledge, better understanding regarding cultivation and management and quality research is indeed in need of an hour so that the economy of the farmers remains unaffected.

REFERENCES

Aggarwal, B. B. and Shishodia, S. 2006 Molecular targets of dietary agents for prevention and therapy of cancer. *Biochem Pharma.* **71**: 1397-1421.

Ahmadian,I. A., Javana, M., Semnanianb, S., Barata, E. and Kamalinejada, M. 2001. Antiinflammatory and antipyretic effects of Trigonella foenum-graecum leaves extract in the rat. *J. Ethnopharmacol* **75**: 283-86.

Arentoft, B. W., Ali, A., Streibig, J. C. and Andreasen, C. 2013. A new method to evaluate the weed-suppressing effect of mulches: a comparison between spruce bark and cocoa husk mulches. *Weed Res*. **53**: 169-75.

Arora, A. and Tomar, S. S. 2012. Effect of soil solarization on weed seed bank in soil. *Indian J. Weed Sci*. **44**: 122-23.

Ascard, J., Hatcher, P. E., Melander, B. and Upadhyay, M. K. 2007. Thermal weed control. In Nonchemical weed management principles, Concepts and Technology. Upadhaya MK, Blackshaw RE (Ed.) CABI, London, UK

Awasthy, P., Bhambri, M. C., Pandey, N., Bajpai, R. K. and Dwivedi, S. K. 2014. Effect of water management and mulches on weed dynamics and yield of maize. *Ecoscan*. **6**: 473-78.

Brown, L., Soltani, N., Shropshire, C., Spieser, H. and Sikkema, P. H. 2007. Efficacy of four corn herbicides when applied with flat fan and air induction nozzles. *Weed Bio. Manag*. **7**: 55-61.

Chaudhary, G.R. 1999. Weed management in fenugreek (*Trigonella foenum graecum*). *Indian J. Agron.* **44**: 846-50.

Chauhan, B. S., Gill, G. S. and Preston, C. 2006. Influence of tillage systems on vertical distribution, seedling recruitment and persistence of rigid ryegrass. *Weed Sci*. **54**: 669-76.

Chovatia, P.K., Jadav, K.V. and Kachhadiya, S.P. 2009. Effects of irrigation schedules and weed management practices on growth and yield of fenugreek (*Trigonella foenum graecum* L.). *Int. J. Agric. Sci.* **5**: 568-71.

Das, T. K. 2008. Weed Science : Basics and application. Jain Brothers Pub, New Delhi, p. 901.

Das, T. K. and Yaduraju, N. T. 2008. Effect of soil solarization and crop husbandry practices on weed species competition and dynamics in soybean- wheat cropping system. *Indian J. Weed Sci.* **40**:1-5.

Das, T. K., Tuti, M. D., Sharma, R., Paul, T. and Mirja, P. R. 2012. Weed management research in India: An overview. *Indian J. Agron*. **57**: 148-56.

Daspute, R.A. and Desai, N.D. and Baviskar, V.S. 2011. Effect of mini-sprinkler and integrated nutrient management practices on growth and yield attributes of fenugreek (*Trigonella foenum graecum* L.). *Int. J. Forestry Crop Imp.* **2**: 85-87.

Dev, D., Vivek., Singh, S. P. and Kumar, R. 2013. Weed management studies in wheat with herbicides under different establishment methods. *Indian J. Agron*. **58**: 215-19.

Dubey, R. P. 2014. Integrated weed management- an approach. In *Training Manual Advance Training in Weed Management*, held at DWSR, Jabalpur, India on 14-23 January, pp. 19-21.

Duke, A.J. 1986. *Handbook of Legumes of World Economic Importance*, Plemus Press, New York and London.

Fagaria, V.D., Gupta K.C. and Saxena, R. 2014. Integrated weed management in fenugreek (*Trigonella foenum graecum* L.) in semi arid regions of Rajasthan. *Int. J. Agric. Sci.* **10:** 302-04.

Fazli, F.R.Y. and Hardman, R. 1968. The spice of fenugreek (*Trigonella foenum graceum* L.). its commercial varieties of seed as a source of diosgenin.

Gerhards, R. and Christensen, S. 2003. Real-time weed detection, decision making and patch spraying in maize, sugarbeet, winter wheat and winter barley. *Weed Res.* **43**: 385-92.

Gopalan, C., Ramasastri, B. V. and Balasubramaniyam, S. C. 1989. *Nutritive Value of Indian Food.* National Institute of Nutrition, ICMR, Hydrabad.

Goswami, S. B. and Saha, S. 2006. Effect of organic and inorganic mulches on soil-moisture conservation, weed suppression and yield of elephant foot yam. *Indian J. Agron.* **51**: 154-56.

Haque Syed Ehteshamul and Ghaffar A. 1992. Effect of *Tricoderma spp*, and *Rhizobium meliloti* in the control of root rot of fenugreek. *Pakistan. J. Biology.* **24**:217-21.

Jadhao, B.J., Patil, B.M., Karunakar, A.P., Dod, V.N. and Joshi, P.S. 1998. Weed management studies in fenugreek (*Trigonella foenum graecum* L.). *J. Soils Crops***. 8**: 150-53.

Kamboj, O. P., Bhatia, A. K., Batra, V. K., Thakral, K. K. and Makhan, Lal 2004. Effect of weed control treatments on weed spectrum and nutrients uptake by weeds in fenugreek. *Haryana J.Hort. Sci.* **33**: 132-34

Kaviarasan, S., Naik, G. H., Gangabhagirathi, R., Anuradha, C. V. and Priyadarsini, K. I. 2007. In vitro studies on antiradical and antioxidant activities of fenugreek (*Trigonella Foenum Graecum*) seeds. *Food Chem* **103**: 31-37.

Kumar, A. Kumar, M. Ghosh, S. Tewari, T. and Bhardwaj, S.B. 2017. Effect of weed management practices in Chrysanmum under tarai conditions of Uttarkhand. *J. Crop Weed*, **13 :** 203-07.

Kumar, M., Ghorai, A. K., Singh, S. R., Majumdar, B., Kundu, D. K. and Mahapatra, B. S. 2012. Effect of stale seedbed and subsequent herbicides application on weeds and rhizospheric microorganism in Jute. In: *Proc. of 3rd Int. Agron. Cong*., Held at IARI, New Sustainable Weed Management 262 Delhi, pp. 304-05

Kumar, S. 2014. Biological control of terrestrial weeds. In training manual advance training in weed management, held at DWSR, Jabalpur, on 14-23 January, pp. 91-95

Manhas, S. S., Gill, B. S., Khajuria and Kumar, S. 2011. Effect of planting material, mulch and FYM on weeds and yield of turmeric. *Indian J. Agron*. **56** : 393-99.

Meena, S. S., Mehta, R. S., Lal, G. and Anwer, M. M. 2013. Economic feasibility of weed management practices in fenugreek. *Indian J. Hort*.; **70**: 150-53

Mehta, R.S., Patel, B.S. and Meena, S.S. 2010. Weed dynamics and yield of fenugreek (*Trigonella foenum graecum* L.) as influenced with irrigation levels and weed management practices. *Indian J. Agri. Sci.* **80**: 970-74.

Mehta, R.S., Patel, B.S., Singh, R.K., Meena, S.S. and Malhotra, S.K. 2010. Growth and yield of fenugreek (*Trigonella foenum graecum* L.) as influenced by irrigation levels and weed management practices. *J. Spices Aromatic Crops*. **19**: 14-22.

Mishra, J. S., Singh, V. P. and Namrata, J. 2010. Long-term effect of tillage and weed control on weed dynamics, soil properties and yield of wheat in rice-wheat system. *Indian J. Weed Sci.* **42**: 9-13

Oerke, E. C. 2006. Crop losses to pests. *J. Agril. Sci*. **144**: 31-43.

Petropoulos, G. A. 2002. *Fenugreek : The Genus Trigonella*. Taylor and Francis, London and New York.

Pruthi, S.S. 1979. *Spices and Condiments*. National Book Trust, New Delhi. 118-23.

Rao, V.S. 2000. *Principles of Weed Science*. Science Publishers, Enfield, New Hampshire. 39–48.

Ryan, M. R., Smith, R. G. and Mortensen, D. A. 2009. Weed: crop competition relationships differ between organic and conventional cropping systems. *Weed Res*.. 49: 572-80.

Sharma, O. L. 2009. Integrated weed management in fenugreek. *Indian J. Weed Sci.,* **41**: 133-35.

Sharma, S. N. and Singh, R. K. 2010. Weed management in rice-wheat cropping system under conservation tillage. *Indian J. Weed Sci*. **42**: 23-29

Singh, R. 2014. *Weed Management in Major Kharif and Rabi Crops*. National Training on Advances in Weed Management. pp. 31-40.

Singh, R. P. and Singh, R. K. 2006. Ecological approaches in weed management. Nat. Symp. on Conservation Agric. and Envi., October 26-28, BHU Varanasi. pp. 301-304.

Smith, R. G., Mortensen, D. A. and Ryan, M. R. 2010. A new hypothesis for the functional role of diversity in mediating resource pools and weed-crop competition in agro-ecosystems. *Weed Res*. **50**: 37-48

Spices Board 2014. *Report of Spices Board*. Ministry of Commerce & Industry, Govt. of India, Cochin.

Talpur, N., Echard, B., Ingram, C. and Bagchi, D. 2005. Effects of a novel formulation of essential oils on glucose-insulin metabolism in diabetic and hypertensive rats. Diabetes Obes Metab **7**: 193-99.

Tiwari, R. C., Bairwa, R. C., Sharma, P. K. and Khandelwal, S. K. 2006. Effect of phosphorus and weed control on fenugreek (*Trigonella foenum-graecum* L.). *Legume Res*.. **29**: 304-07

Tripathi, S.S. and Singh, G. 1993. Crop-weed competition studies in fenugreek (*Trigonella foenum graecum* L.). *Proc. Indian Soc. Weed Sci.* **11**: 41-43.

Tripathy. S. and Bastia, D. K. 2012. Irrigation and nutrient management for yield augmentation of summer sesame (*Sesamum indicum* L.). *J. Crop Weed.* **8**:53-57.

Tu, 2012. Manual & Mechanical Control Techniques. The Nature Conservancy. Retrieved 4.

Vasileiadis, V. P., Froud- Williams, R. J. and Eleftherohorinos, I. G. 2006. Vertical distribution, size and composition of the weed seedbank under various tillage and herbicide treatments in a sequence of industrial crops. *Weed Res*. **47**: 222-30.

Verma, S. K. 2014. Enhancing sustainability in wheat production though irrigation regimes and weed management practices in eastern Uttar Pradesh. *The Ecoscan*. **6**: 115-19.

Verma, S. K. and Singh, S. B. 2008. Enhancing of wheat production through appropriate agronomic management. *Indian Farming*. **58**: 15-18.

Yadav, P.K., H. Kumar., Soni, A.K. and Bairwa, S.K. 2013. Yield and water use efficiency of fenugreek as influenced by drip irrigation. *Indian J. Fertilisers*. **9**: 38-40.

Zimdahl, R. L. 2007. Fundamental of weed science. Academic Press, Burlington, MA.