IMPLICATIONS OF WEEDS OF GENUS EUPHORBIA FOR CROP PRODUCTION: A REVIEW[1]

Implicações de Plantas Daninhas do Gênero Euphorbia na Produção de Culturas: Uma Revisão

TANVEER, A.[2], KHALIQ, A.[3], JAVAID, M.M.[4], CHAUDHRY M.N.[5], and AWAN I.[6]

ABSTRACT - The genus *Euphorbia* comprises about 2000 species ranging from annuals to trees, including C_3, C_4, and CAM species. Euphorbia species widely studied in agriculture includes *E. antiquorum*, *E. carollata*, *E. dentata*, *E. dracunculoides*, *E. esula*, *E. geniculata*, *E. granulata*, *E. helioscopia*, *E. heterophylla*, *E. hierosolymitana*, *E. hirta*, *E. maculata*, *E. microphylla*, *E. nerifolia*, *E. piluifera*, *E. pulcherrima*, *E. royleana*, *E. supine*, and *E. thiamifolia*. These species have been reported mainly in field crops/vegetables, orchards, pastures, and rangelands. Euphorbia plants may present allelopathic effect over desirable cereals, pulses, oilseeds, vegetables, forage plants, and nitrifying bacteria, posing a serious threat to livestock production on open range lands through the release of allelochemicals from roots, stems, leaves, and inflorescence in the rhizosphere. Leaves are reported to be more toxic than other plant parts. Competition of *Euphorbia* spp. against crop plants is the most important crop yield-limiting factor. The critical period for Euphorbia competition with crops is reported to take place between 17 to 70 days after emergence for most crops, depending on root development during the initial crop growth stage, crop height, tillering or branching capacity, whether weeds emerge at the same time as the crop or later after crop emergence; how quickly crop canopy develops and also on Euphorbia species. A yield reduction of 4-85% has been reported in field crops with different Euphorbia species and distinct occurrence densities. Euphorbia species decrease herbage production by 10 to 100% in pasture and rangelands, with many acting as natural insecticide, fungicide, nematidicide, immunopotentiator, or immunosuppressor.

Keywords: competition, allelopathy, crops, pastures, livestock, plant protection.

RESUMO - O gênero ***Euphorbia*** *compreende cerca de 2.000 espécies, que variam de plantas anuais a árvores, incluindo C3, C4 e espécies CAM. As espécies de* ***Euphorbia*** *amplamente estudadas na agricultura incluem* ***E. antiquorum***, ***E. carollata***, ***E. dentata***, ***E. dracunculoides***, ***E. esula***, ***E. geniculata***, ***E. granulata***, ***E. helioscopia***, ***E. heterophylla***, ***E. hierosolymitana***, ***E. hirta***, ***E. maculata***, ***E. microphylla***, ***E. nerifolia***, ***E. piluifera***, ***E. pulcherrima***, ***E. royleana***, ***E. supina*** *e* ***E. thiamifolia****. Essas espécies têm sido relatadas principalmente em culturas de campo, legumes/pomares, pastagens e pastagens. Plantas de* ***Euphorbia*** *podem apresentar efeito alelopático sobre cereais, leguminosas desejáveis , oleaginosas, vegetais, plantas forrageiras e bactérias nitrificantes, o que representa uma séria ameaça para a produção de gado em terras abertas, através da liberação de aleloquímicos de raízes, caules, folhas e inflorescências na rizosfera. As folhas são mais tóxicas do que outras partes da planta. A competição de* ***Euphorbia*** *spp. com plantas de cultivo é o mais importante de todos os fatores que limitam a produtividade das culturas. O período crítico da competição de* ***Euphorbia*** *com as colheitas é relatado como sendo entre 17 e 70 dias após a emergência para a maioria das culturas, dependendo do desenvolvimento de raízes durante o estádio inicial de crescimento da cultura, da altura da cultura, do afilhamento ou ramificação de capacidade, se as plantas daninhas surgem ao mesmo tempo com a cultura, ou mais*

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2 Department of Agronomy, University of Agriculture, Faisalabad, Pakistan, <drasiftanveeruaf@hotmal.com>, corresponding author; 3 Department of Agronomy, University College of Agriculture, University of Sargodha, Pakistan. 4 University College of Agriculture and Environmental Sciences, The Islamia University of Bahawalpur, Pakistan, 5 Department of Agronomy, Gomal University, D.I. Khan, Pakistan.

tarde, após a emergência da cultura, da rapidez com que o dossel da cultura se desenvolve e também das espécies desse gênero. Uma redução no rendimento de 4-85% tem sido relatada em colheitas de campo com diferentes espécies de ***Euphorbia*** *e densidades distintas de ocorrência. Essas espécies diminuem a produção de forragem de 10 a 100% em pasto e pastagens. Muitas delas atuam como inseticida natural, fungicida, nematidicide, imunopotenciador ou imunossupressores.*

Palavras-chave: competição, alelopatia, lavouras, pastagens, pecuária, proteção de plantas.

INTRODUCTION

The genus *Euphorbia*, belonging to the Euphorbia family, comprises about 2000 species ranging from annuals to trees (Shi & Jia, 1997). The genus *Euphorbia* is a structurally and physiologically diverse taxon and includes C_3, C_4 and CAM species (Downtown, 1971). To date, more than 60 C_4 species have been detected within the genus (Downtown, 1975; Raghavendra & Das, 1978), and 18 species have been reported to have CAM physiology (Szarek, 1979). The extensively investigated species of *Euphorbia* includes *Euphorbia dentata* (toothed spurge) in corn, soybean and sunflower (Juan et al., 1996, 2003); *E. esula* (leafy spurge) in range and recreational lands (Dunn, 1979; Steenhagen & Zimdahl, 1979; Singh et al., 2000), monocrop land habitats (Selleck et al., 1962); *E. dracunculoides* (dragon spurge) in wheat, chickpea and mustard (Singh et al., 1995; Ponia et al., 1997; Shanee et al., 2011); *E. geniculata* (painted spurge) in orchards of loquat, mango, guava, citrus group, grapes and ber (*Zizyphus jajuba*) (Sindhu & Bir, 1987), soybean and chickpea (Jain & Tiwari, 1993; Mishra & Singh, 2003); *E. granulata* (prostrate spurge) in lawn, cultivated field, onion (Hussain, 1980; Sadaqa et al., 2010); *E. helioscopia* (sunspurge) in wheat, lentil, chickpea, potato and pea (Ghafoor & Shad, 1990; Tanveer et al., 2010; Bharat & Kachroo, 2007, 2010) and as a medicinal plant (Jiangbo et al., 2010); *E. heterophylla* (wild poinsettia or painted spurge) in Kersting's ground bean (*Macrotyloma geocarpa*), soybean, cowpea, cotton, sugarcane, peanut (Harger & Naster, 1980; Akobundu & Agyaka, 1987; Eniola & Fawusi, 1989; Adelusi & Akamo, 2006); *E. hierosolymitana* (spurge) in wheat, orchards (Romman et al., 2010); *E. hirta* (Pill-bearing spurge) in rice - mung+sesame system (Ramanjaneyulu et al., 2006); chilli, maize, mustard (*B. juncea*) (Sandhu et al., 1999; Rajput et al., 2003; Singh & Agarwal, 2004; Kumar et al., 2009; Jabeen & Ahmad, 2009); *E. maculata* (spotted spurge) in cotton, soybean (Bannon et al., 1978; Dale & Chandler, 1979; Dunn, 1979); *E. microphylla* in citrus (Josan et al., 2003); *E. supina* (prostate spurge) in cotton, soybean (Bannon et al., 1978; Dale & Chandler, 1979; Dunn, 1979); *Euphorbia* spp. in rice (Kumar et al., 2009; Yadav et al., 2009), and *E. thiamifolia* (thyme-leaf spurge) in *Cajanus cajan*, *Vigna radiata*, *V. uriculata* and *Cicer arietinum* (Kumbher & Dabgar, 2010, 2011). The present review discusses the competition and allelopathic effects of genus Euphorbia weeds on other weeds, crops, pastures and livestock along with their plant protection potential.

Euphorbia spp. competition with crops

Weed density, duration, species, area of influence and agro-management practices are used to determine the extent of damage caused by the competition of a weed species within a crop. Duration of weed competition, often called the critical period, defines the maximum period in which weeds can be tolerated without affecting final crop yields. A 10-wk *E. heterophylla* – free period was required to prevent peanut (*Arachis hypogaea*) yield losses (Bridges et al., 1992). A period of 3-4 weeks after planting is the critical period of *E. heterophylla* competition in cowpea (*Vigna unguiculata*) (Olorunmaiye & Ogunfoloji, 2002). The critical period for *E. heterophylla* competition in soybean was reported to be between 17 to 44 days after emergence (Meschede et al., 2002), while Adelusi et al. (2006b) stated that the critical weed free period falls between 28 to 38 days in *E. heterophylla* – soybean competition.

Yield losses by a specific weed vary from crop to crop. Soybean and peanut have suffered yield losses of 30 and 50%, respectively, due to the presence of *E. heterophylla* (Bannon et al., 1976; Nester et al., 1979; Bridges et al., 1992; Willard & Griffin, 1993). Competition for more than 2 weeks resulted in 8% or greater soybean yield reduction by *E. heterophylla* (Bridges et al., 1992). Meschede et al. (2002) stated that presence of *E. heterophylla* in soybean during the whole cycle caused a yield loss of 5.15 kg ha^{-1} per day. According to Kissmann (1992), yield losses in soybean due to *E. heterophylla* can reach up to 80% depending on management practices. It could be attributed to higher water-use efficiency and net photosynthesis of *E. heterophylla* than soybean (Procopio et al., 2004). Olorunmaiye & Ogunfolaji (2002) reported reduction in growth, yield and yield components of cowpea with increase in *E. heterophylla* competition duration from 3 to 6 weeks after planting.

Willard et al. (1994) studied *E. heterophylla* – soybean competition using area of influence methodology under field condition and recorded more reduction in soybean canopy, dry weight (after 6, 12, 18 weeks) and yield with 0 to 10 and 10 to 20 cm distances compared with the 80 to 100 cm distances from the weed. The degree of weed interference also depends on the density of the weeds infesting the crop. Research conducted by Bridges et al. (1992) indicated that *E. heterophylla* caused a peanut yield loss of 4 to 54% at densities of 1 to 32 plants per 9 m of row. Growth (plant height, number of leaves, dry matter accumulation) and macronutrient accumulation of soybean in co-existence with *E. heterophylla* were reduced with increasing densities of *E. heterophylla* (Rizzardi et al., 2004; Carvalho et al., 2010). Increase in *E. heterophylla* density from 1 to 10 per pot reduced the growth, yield and yield components of cowpea (Olorunmaiye & Ogunfolaji, 2002). Yield reduction in cowpea with increasing density of *E. heterophylla* was also reported by Remison (1978). Weed management studies at the International Institute of Tropical Agriculture, Ibadan, Algeria, revealed that a density of 10 plants m^{-2} of *E.heterophylla* reduced cowpea yield by 25-53% while 80 plants m^{-2} reduced yield by 68-75% (IITA, 1977).

Jain & Tiwari (1993) and Mishra & Singh (2003) advocated that *E. geniculata* dry weight and density have significant negative correlation with the soybean yield which linearly decreased with increased weed dry weight/density. Increasing densities of *E. geniculata* from 10 to 120 plants m^{-2} reduced the seed yield of soybean by 12-30% and chickpea by 18-53% in soybean-chickpea cropping system, indicating that at the same density, chickpea was more susceptible to this weed than soybean (Mishra & Singh, 2003). *Euphorbia dentata* interference at a density of 20 plants m^{-2} resulted in a soybean yield reduction of 80%. Seed production decreased by 673 kg ha^{-1} for each plant m^{-2} increase of *E. dentata* (Juan et al., 2003). Seed cotton yield reduction was 47, 57 and 85% for *E. maculata* densities of 5, 10 and 50 plants m^{-1} of row due to a reduction in growth and yield components of cotton (Bararpour et al., 1994).

The degree of competition offered by a particular weed also depends on associated crops and the behavior of other weeds. Adelusi et al., (2006a,b) reported more competitive behavior of Kersting's ground bean (*Macrotyloma geocarpa* (Harms) Marechal and Baudet) than *E. heterophylla* with increasing N levels as the crop performed better in terms of growth and yield. Similarly, *E. heterophylla* exhibited less competitive superiority in mixture with *Senna obtusifolia* (Awodoyin & Ogunyemi, 2008)

Allelopathic effects of *Euphorbia* species on field crops

Several studies have been conducted on the phytotoxicity of *Euphorbia* species extracts. Aqueous extracts of stems, leaves and roots of leafy spurge inhibited wheat germination and seedling growth of wheat, peas and several other species (Le Tourneau, 1951; Le Tourneau et al., 1956; Le Tourneau & Haggeness, 1957). Leaves were more toxic than stems and roots (Le Tourneau et al., 1956), which was confirmed later on by Selleck (1972). Variation in the allelopathic response of different plants depends upon the distribution and accumulation of allelochemicals in different parts of weeds. Reduction in seedling growth of maize and wheat, delayed germination, reduced chlorophyll and protein content of wheat with aqueous extract of *E. hirta* and

E. hierosolymitana at high concentration has been reported by Jabeen & Ahmad (2009) and Romman et al. (2010), respectively. The effect of *E. hirta* on maize was concentration dependent. At low concentration, it promoted seedling growth of maize (Jabeen & Ahmad, 2009). It means this extract could be used as a growth inhibitor or stimulator for crops depending upon the dose of application.

Aqueous extract of *E. thiamifolia* leaf, stem, root and inflorescence significantly inhibited the germination, seedling growth and weight of *Cicer arietinum*, *Cajanus cajan*, *Vigna radiata* and *V. uriculata* (Kumbhar & Dabgar, 2010; Kumbhar & Dabgar, 2011). Effect of *E. thiamifolia* plant parts was crop dependent. Kumb & Dabgar (2010) stated that leaf extract had the most inhibitory effect followed by those of the stem, root and inflorescence, on *C. arietinum*, *C. cajan*, *V. radiata* and *V. uriculata*, while Kumbhar & Dabgar (2011) reported the most inhibitory effect of *E. thiamifolia* stem followed by those of leaf, inflorescence and root on *C. cajan*.

Extracts from the root, stem, leaf and fruit of *E. helioscopia* reduced the seed germination of chickpea, lentil and wheat with greater inhibitory effect of leaf (Qasem, 1995; Tanveer et al., 2010). But at low concentration, leaf, stem and root extracts of this weed stimulated seed germination of tested crops as compared to control. It can be concluded that allelochemicals which inhibited germination of some species at certain concentrations, might stimulate the germination of the same or different species at lower concentration.

Tiwari et al. (1985) noted a detrimental effect of root washings of *E. hirta* on germination and early seedling growth of soybean, groundnut and green gram. Sughar (1979) reported inhibitory effect of *E. geniculata* on wheat.

Allelopathic effects of *Euphorbia* on other weeds

Aqueous extract of *E. granulata* significantly inhibited germination and radical growth of *Dicanthium annulatum, Cynodon dactylon, Setaria italica, Pennisetum americanum, Euphorbia pilulifera, Oxalis corniculata* and *Lactuca sativa* (Hussain, 1980). According to Ibrahim et al. (1985), extracts from *E. supina, E. pilulifera, E. acalyphoides, E. prunifolia, E. hirta, E. aegyptiaca, E. splendens*, and *E. granulata* were most active in inducing germination of Striga hermonthica seeds. Extracts from *E. acolyphoides* and *E. pilulifera* were inhibitory at high concentration. Aqueous extract, decaying residues, root extract and soil under *E. prostrata* stands were inhibitory to seed germination and seedling growth of *C. dactylon* (Alsaadawi et al., 1990). Olson & Wallander (2002) reported similar results by recording shorter roots of two perennial grasses (*Pseudoroegneria spicata*, *Pascopyrum smithii*) with higher leachate concentrations of *E. esula*.

Allelopathic effects of *Euphorbia* infested/rhizosphere soil

The donor plants release allelochemicals into surrounding environment through leachates, root exudates and volatilization and, hence, accumulation of allelochemicals causes toxicity, affecting crop growth and yield. Field soil samples taken from areas of moderate and high leafy spurge densities or incorporation of leafy spurge leaves, roots or litter into the soil inhibited seedling growth of tomato (*Lycopersicon esculentum*) and crabgrass (*Digitaria sanguinalis*. Reduction in frequency and density of quackgrass (*Agropyron rapens* and common ragweed (*Ambrosia artemisiifolia*) were noted where leafy spurge had high densities in the field (Steenhagen & Zimdahl, 1979). Hussain (1980) reported significant germination inhibition and root growth of *D. annulatum*, *C. dactylon*, *S. italica*, *P. americanum*, *E. pilulifera*, *O. corniculata* and *L. sativa* with *E. granulata* underlying soil. Inhibitory effect of *E. granulata* infested soil was further confirmed by Sadaqa et al. (2010) in onion. Results similar to these findings were reported by Tanveer et al. (2010) for wheat, chickpea and lentil with *E. helioscopia*.

Inhibitory effect of *E. corollata* and *E. supina* on nitrifying bacteria and several strains of N-fixing bacteria in soil was documented by Rice (1965, 1969).

***Euphorbia* interference in pasture/ rangeland and livestock**

Undesirable plants in grazing land often reduce forage production by competing with native plants and discouraging grazing near the plant, thereby directly affecting the land's usefulness for livestock grazing (Auld et al., 1987; Huenneke, 1995). Leafy spurge is an aggressive perennial weed that readily competes with desirable vegetation in pasture and rangelands (Messersmith, 1983) and decreases herbage production by as much as 75% (Lym & Kirby, 1987). Derscheid & Wrage (1972) and Reilly & Kaufman (1979) have reported yield reductions of associated desirable forage species from 10 to 100% with leafy spurge. These losses depend on weed density and competition duration. Lym & Kirby (1987) experienced a decrease in annual herbage production of at least 35% in grazed rangelands infested with leafy spurge densities of 50 or more. It tends to displace all other vegetation after establishment in pasture and rangeland habitats (Selleck, 1972; Steenhagen & Zimdahl, 1979; Lym & Kirby, 1987) to establish essentially a single species stand through allelopathy by releasing flavanoid compound Kaempherol glucuronide (Selleck et al., 1962), compared to adjacent areas. The plant is toxic to livestock (Selleck et al., 1962) and poses a serious threat to livestock production on open rangelands. Cattle and horses avoid grazing lands of leafy spurge because of chemical irritants in the plant (Muenscher, 1940; Lym & Kirby, 1987). Although leafy spurge is not utilized by cattle, it is readily grazed by sheep and goats (Landgraf et al., 1984). The latex (milky juice) in leafy spurge is a skin irritant that can cause severe dermatitis in grazing animals (Kingsburry, 1964; Upadhyay et al., 1978). The latex also causes scours and weakness in cattle and may result in death (Muenscher, 1940, 1948, 1960; Kingsbury, 1964). There appear to be many toxic substances in the spurge latex, and the latex has been demonstrated to contain cocarcinogenic factors (Upadhyay et al., 1978).

***Euphorbia* allelopathy and plant protection**

Many scientists have highlighted the significance of *Euphorbia* species against insects, virus, fungus and nematodes. Govindaiah et al. (1997) reported that *Euphorbia* species were least effective against root knot nematode (*Meloidogyne incognita*) infecting mulberry. On the other hand, Bhatti et al. (1997) reported effective reduction in hatching of larvae of cyst nematodes (*Heterodera avenae* and *H. cajani*) with *Euphorbia hirta*. Total larval mortality of *Meloidogyne incognita*, *M. javanica* and *M. arenaria* was observed in *Euphorbia pilulifera* extract (Hussaini et al., 1996). Uma & Kumar (2009) reported insecticidal property of *Euphorbia antiquorum*, *E. pulcherrina* against *Plutella xylostella*. Inhibitory activity of *E. hirta*, *E. antiquorum* and *E. royleana* against ride guard mosaic virus has been stated by Tripathi & Sharma (2007). According to Sahani & Saxena (2009), *E. nerifolia* exhibited absolute toxicity (98.0%) against *Fusarium oxysporum*. Antibacterial and antifungal activity of *E. hirta* was also reported by Barate et al. (2008). Effect of *E. hirta* on immune system of poultry was studied by Zafar et al. (2006). *Euphorbia hirta* leaf extract at lower doses (10 mg kg^{-1} body weight) acts as an immune potentiator and as an immune suppressor at higher doses (100 mg kg^{-1} body weight).

Allelochemicals in *Euphorbia* species

The production of phytotoxic natural products by weeds is a mechanism by which these species may become successful competitors. Elmore & Paul (1983) reported high concentration of phenolics in *E. supina* and *E. maculata*, which is supported by previous findings of Rice (1969), who reported phenolics and gallic acid in *E. supine*. Wanger et al., (1970), Manners & Wong (1985), Manners (1987), Manners & Davis (1987) and Qin et al. (2006) have identified several phototoxins, including relatively strong phytotoxins Kaempferol-3-glucuronide and I-hexaconsanol in aqueous extracts of the whole plant, and moderately diterpenes jatrophane in leafy spurge roots. *Euphorbia esula* (Evans & Kinghorn, 1977; Roberts & Olson, 1999; Zhi Qiang et al., 2008) and *E. heliescopia* (Jiangbo et al., 2010) contains di- and tri- terpenoids and condensed tannins.

This review has concluded that the *Euphorbia* species if allowed to grow and stand for full or partial life span of the main crop could cause a serious impediment in the germination and early seedling establishment of crops and, thus, limit their yield. Furthermore, *Euphorbia* species have herbicidal and insecticidal properties but there is the need to establish their commercial utility potential as environment friendly plant protection measures.

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