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Allelopathy of waste-land weeds: A review

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Abstract
Allelopathy is a naturally occurring ecological phenomenon of interference among different crops. Waste-land weeds are present all around the field and hamper the germination and growth of crops. They also compete with crops and reduced the seedling development processes of various crops through the production and release various allelochemicals. These chemicals may inhibit or support the germination and development of neighboring plants. Various weeds like *Parthenium hysterophorous* L., *Achyranthes aspera* L., *Lantana camara* L. and *Withania somnifera* L. grown at waste-lands and create problems during the crop germination and reduced efficiency of farm practices. In this review we will discuss the phytotoxic effect of various waste-land weeds on performance of germinating seed through its leachates and rhizospheric soils.

Keywords: allelopathy, waste-land, germination, seedling

1. Introduction

Weeds are plants emerged and develop at places, in time and wealth not wanted in light of the fact that they meddle with land and water assets, and meddled with human welfare. These might be dichotomized into rural weeds those harming to cultivating, and natural or bush land weeds – those damaging to local vegetation and faunas (Arcioni, 2004) [6]. Weed is a plant strange and not deliberately planted or a plant whose temperance's have not yet found, plants that are serious, malicious, steady and meddle contrarily with human action. Contingent upon their life cycle Weeds are ordered into three sorts viz; annuals, biennials and perennials. Weed impact on crop plants and decrease in crop yield both in real cash and bulk (Furtick, 1970; Krishnamoorthy and Chowdhury, 1974) [25, 46]. They are essentially contending with crops for water, supplement, light and space (Hill, 1977) [32]. Crop- land weeds for the mostly develop in crop field or alongside the crop plants and rival light, supplement, space and water. The vast majorities of the harvest land weeds are annuals or grow and produce seed inside one season. In Pakistan per acre yield of crops is lower than lower than other developed country such as yield of wheat in Pakistan is 2787 kg ha^{-1} while the world; normal yield is 3210 kg-1 (FAO, 2011) [24]. Plants that discharge allelochemicals may influence germination, development and improvement of the closest plant species (Einhellig, 1987) [21]. Synthetic compounds that are discharged from plants are known as allelochamicals. Green plants produce many thousands exacerbates that are not engaged with the essential digestion of the plants. The compound engaged with entomb explicit synthetic communication inside higher plants are frequently phytotoxic or herbicidal to different species or even to the species delivering them (Duke, 1986) [19].

A great part of the considerations of weed researcher stay on the crop land weeds because of their concern made in crop field by the rancher. Be that as it may, next to no examination has yet been centered around the hurtful impact of waste land weeds present on the edge of our yield field. These weeds influence crop by their allelopathic impact through leaf leachates, rhizospheric soil and decayed item. During soil readiness, the dirt underneath weeds of field outskirt become blended in with field soil and restrains the germination and development of present and consequent yield. Keeping in see the significance of waste land weeds, contemplates has yet been intended to examine the allelopathic impact of *L. camara*, *P. hysterophorous*, *W. somnifera* and *A. aspera* on some winter season crops.

2. Allelopathy

Olofsdotter (1998) [57] firstly studies on allelopathy in forest ecosystem. It was initially documented that number of the forest species has been negative allelopathic effect on the food and fodder crops. Jalali *et al.* (2013) [35] investigated that both positive and negative influence of allelochemicals discharge from plants by defining allelopathy as the ability of plant may be, they inhibit or stimulate growth of other plant in the environment by releasing chemicals.

Khalaj *et al.* (2013) [42] demonstrated that allelochemicals are plant secondary metabolites normally release into environment through leaching, root exudation volatilization and decomposition of dead plant or residues in soil. Allelochemicals are secondary metabolites synthesized by almost all plants but do not have a direct role in their growth, development and reproduction (Bertin *et al.*, 2003) [8]. When susceptible plants are exposed to allelochemicals, germination, growth and development may be effected. Allelochemicals are present in different parts of plants that are known to interfered seed germination and growth of neighboring or succession plants by releasing allelochemicals in their environment (Einhellig, 1995) [20]. Kashif *et al.* (2015) [41] determined that wheat cultivars had different allelopathic inhibition activity on the littleseed canarygrass through the production of phenolic compounds. Maximum inhibition in shoot length (59%), root length (54%), shoot dry weight (55%) and root dry weight (60%) of littleseed canarygrass was recorded when grown in association with wheat cv. Shafaq-06. Significant increase in production of total soluble phenolics was also observed in shoot and root of all wheat cultivars when wheat grown in association with canarygrass as compared to grown alone. (Liebl and Worsham, 1983) [50] also investigated that wheat has been examined extensively for its differential allelopathic potential among accessions. Wheat contains some allelochemicals like phenolic compounds that can inhibit weed growth under the field conditions. Root length of wheat showed the most sensitivity to release allelochemicals from wheat because root has the direct contact with allelochemicals. The deleterious effects of allelochemicals are more prominent on seed germination and seedling growth of different crops (Bogatek *et al*., 2006) [11]. Allelopathic phenomenon in soil is further intricate by soil conditions as availability, movement and uptake of allelochemicals are strongly associated with soil physical and bio-chemical properties (Kobayashi, 2004) [45]. Through root exudation allelochemicals are deposited into rhizosphere (Kobayashi, 2004) [45]. According to an estimate, 30% of plant's synthesized products are utilized in the production of root exudates, which influence localized soil environment (Bertin *et al.*, 2003) [8].

3. *Parthenium hysterophorous*

Previous bioassay studies have shown the negative allelopathic effects of different plant parts of *P. hysterophorous* on germination and growth of maize and other crops such as wheat (*Triticum aestivum* L.), ryegrass (*Lolium multiflorum* Lam.), black gram (*Vigna mungo* L.), soybean (*Glycine max* L.), haricot bean (*Phaseolus vulgaris* L.), sorghum (*Sorghum vulgare* Pers.), cotton (*Gossypium hirsutum* L.), green gram (*Vigna radiate* L.), arhar (*Cajanus cajan* L.), lettuce (*Lactuca sativa* L.), ground nut (*Arachis hypogaea* L.), sunflower (*Helianthus annuus* L.) and pearl millet (*Pennisetum glaucum* L.) (Mersie and Singh, 1987; Gupta, 2008; Kumar and Gautam, 2008; Dhole *et al.*, 2011) [48, 30, 54, 14]. In the majority of the studies, its leaf and flower were proved to be more deleterious than its stem and root (Marwat *et al.*, 2008; Khan *et al.*, 2011, Gella *et al*., 2013) [52,38,28] and their aqueous extracts at higher concentrations were proved to have more phytotoxic action compared with their lower concentrations (Kumar and Gautam, 2008; Devi and Datta, 2012; Demissie *et al*., 2013) [47,15.14]. However, the degree and nature of inhibitory reaction is crop specific and varied with parthenium plant parts and concentrations.

Khan *et al*. (2012) [44] conducted an experiment to examine the effect of aqueous extract of parthenium leaf, stem and root on different wheat cultivar. The results showed that the leaf treatment was superior among all other treatments in germination inhibition, root and shoot weight, seedling root/shoot weight. In addition, the seedling of wheat cultivar (Sim) has also shown better resistance to the parthenium extracts of root, stem and leaf than the other cultivars. The seed germination of wheat cultivar (Siran) was comparatively less inhibited by the parthenium extracts than the other wheat cultivars. Similarly, the seed germination as well as the seedling growth of wheat cultivar (Lasani) was the most inhibited one by the parthenium root, stem and leaf extracts. According to (Evans, 1997) [23] the invasive ability and allelopathic properties of *Parthenium hysterophorus* possess a great risk to disrupt ecosystem. According to (Masum *et al.*, 2013) [53] if alien weeds parthenium become associated weed of crop, the crop production will be highly hampered and side by side human and animal health will be a hazardous condition. Devi *et al*. (2014) [16] documented that aqueous extract of leaf and stem of *Parthenium hysterophorous* L. inhibit 91.6% of seed germination of maize. Parthenium dry biomass incorporate in the soil significantly reduced the seedling growth and germination of maize seed and population density also effect on dry biomass production and plant height. Khan *et al.* (2011) [43] reported significant reductions in germinations and seedling growths of soybean, mungbean and maize by aqueous leaf extracts of parthenium with 25 g L^{-1} and 50 g L^{-1} concentrations.

Biswas *et al*. (2010) [10] conducted an experiment to determine the effect of parthenium debris in the soil. Debris of different concentration of *P. hyterophorous* in the soil reduced the seedling emergence 25.40%, plant height 20.98%, leaf number 20.02%, leaf area 33.85% and dry weight 22.78 % were reduced. Among all the parameter leaf area was most affected than all other. The inhibitory effect on rice was positively related to parthenium weeds debris in soil. According to (Devi and Dutta, 2012) [15] reported that leaf aqueous extract of *p. hysterophorous* and *chromolaena odorata* L. show significantly inhibition of germination, plumule, radical and growth of seedling of maize (*Zea mays* L.). However, 10% aqueous extract show highest degree of inhibition of radical and plumule growth of maize. Demissie *et al.* (2013) [14] conducted an experiment to evaluate the allelopathic effect of *Parthenium hyterophorous* L. on the germination and elongation of *Allium cepa* and *Phaseolus vulgaris*. Different concentration of plant extract was prepared. Seed germination rate were slightly similar at lower concentration when compared with control group. At higher concentration rate of germination and rate of elongation was significantly decline. Furthermore, the biomass study of bean and onion at higher concentration was found about 50% lesser than control. It concludes that aqueous extract of parthenium contain allelopathic effect which could affect the germination and elongation of onion and bean.

Kumar and Kumar (2010) [48] conducted an experiment to investigate the effect of *Parthenium hysterophorous* L. ash on germination, radical and plumule and biomass production of *Phaseolus mungo.* Study revealed that low concentration of parthenium ash 1% enhanced the germination, radical and plumule length and biomass production and decreased by increasing the concentration of ash. Study conclude that increase concentration of ash has negative effect on germination, plumule and radical length, biomass of *P. mungo* compared with control therefore burning of parthenium should be avoided in fields to enhanced the overall productivity of *P. mungo.* Bhimarao *et al.* (2015) [9] investigated that leaf extract of *Parthenium hysterophorous* L. show significantly inhibitory effect on germination, shoot and root elongation and biomass production of *Trigonellafoenum graecum* L. and *Vigna aconitifolia* L. Bioassay specify that inhibitory effect was proportional to seeds soaking hour and concentration of extract. Maharjan *et al*. (2007) [51] conducted an experiment to evaluate the allelopathic effect of *Parthenium hysterophorous* L. leaf extract on seed germination of three cereal crops *Zea mays* L., *Oryza sativa* L., *Triticum aestivum* L. and three cultivated crucifer *Raphanus sativus* L., *Brassica oleracea* L. and *Brassica campestris* L. and two wild species *Artemisia dubia wall* and *Ageratina adenophora*. Result revealed that seed germination of all crucifer was completely inhibited at 2% leaf extract of parthenium; other species except maize completely fail to germinate was recorded at 6% *T. aestivum* and *A. adenophora*; at 10% *O.sativa* and *A. dudia*. Germination of maize was not completely inhibiting but it was low at higher concentration of leaf extract. Leaf extract had stronger inhibitory effect to root elongation of cereals and shoot elongation in crucifers and wild species. According to (Marwat *et al*., 2008) [52] increased concentration of *P. hysterophorous* extract, germination percentage, seedling length, seedling weight of *Triticum aestivum* L., *Avena fatua* L., and Lepidium sp. Field experiment showed there was no significantly inhibitory effect either used as post or pre-emergence herbicide. However different concentration had significantly effect on weeds density. So, parthenium used as bioherbicides.

4. *Lantana camara*

Lantana camara L. is known as both a notorious weed and famous ornamental plant. Allelopathy involved both stimulatory and inhibitory interaction between plants. Lantana allelopathic effect studies have been done with many crops, shrubs, trees and weeds under both laboratory and field conditions. Lantana inhibits the germination and growth of crops, weeds vegetables and bryophytes (Mishra, 2015) [55]. The different parts of *Lantana camara* contain allelochemicals mainly aromatic alkaloids and phenolic compounds (Ambika *et al*., 2003) [4] which can interfere with seed germination and early growth of many plant species (Gentle and Duggin, 1997; Ahmed *et al*., 2007) [29,1]. *Lantana camara* can also interfere growth of plants by competing for soil nutrients (Dobhal *et al*., 2010) [18]. Jawahar *et al*. (2010) [38] determined that different concentrations of aqueous extract of lantana caused significant inhibitory effect on the germination, root, and shoot elongation of *Trianthema portulacastrumand* and bioassay of lantana also indicate that aqueous extract of lantana 50% concentration had stronger inhibitory effect on *T. portulacastrumand* the decrease thereafter. Hussain *et al*. (2011) [34] demonstrated that aqueous extract of all part of lantana camara have strong allelopathic effect on the germination and growth of *Pennisetum americanum, Sataria italic* and *Lactuca sativa*. Hot water extract from leaves were more toxic than stem and fruit extract. Alcoholic extract did not affect the germination of test species. Natural rain leachates of different plant parts invariably suppressed the germination and growth of various test species. Lantana soil when tested showed no inhibitory effects on the germination and growth of test species. Soil analysis indicated that CaCO3 and organic matter were low in control soil compared with lantana-affected soil.

Gantayet *et al*. (2014) [26] conducted an experiment to understand the allelopathic effect of *Lantana camara* L. leaf-litter dust on vegetative growth of green gram. The leaf-litter dust of *L. camara* caused significant inhibitory effect of yield and vegetative growth of green gram. Studies indicate that the leaf-litter dust released allelochemicals into the soil. Enyew and Raja (2015) [22] concluded that *L. camara* leaf powder significantly inhibit the seed germination, speed of germination, root and shoot length, stem thickness and biomass of wheat and maize. By keeping the *L. camara* plants around agricultural field may affect growth of wheat and maize. (Angiras *et al*., 1988) [5] found that aqueous extract of lantana reduced the germination of chickpea. According to (Hossain and Alam 2010) [33] who determined that the different leaf extract of *L. camara* caused significantly inhibitory effect on germination, shoot and root elongation and lateral root development of receptor crops (both agricultural and forest crops) and bioassay also inhibit. Higher concentration shows stronger inhibition whereas, in some cases lower concentration show stimulatory effect. According to (Enyew and Raja, 2014) [22] investigated that the lantana leaf powder significantly inhibits the germination of seeds, speed of germination, root shoot length, stem thickness and biomass of wheat and maize. If *L. camara* present in the field they may affect the yield parameters of wheat and maize. Kar *et al*. (2014) [40] who documented that leaf aqueous extract of *L. camara* caused significantly inhibitory effect on germination, shoot and root elongation and relative biomass and bioassay also had stronger inhibitory effect on *Pisum sativum* L. whereas 10% lowest concentration show stimulatory effect in some cases. Explants obtained from the apical, middle and basal parts of Pogonatum aloides were allowed to regenerate with half knop's liquid culture medium supplemented with *L. camara* different concentration of leaf, stem and root extract. According to Mishra and Singh (2010) [56] who investigated that the stem, leaf, fruit and flower extract of *Lanatana camara* L. inhibit the germination of *Parthenium hysterophorous* L. seed. It clearly shows that lantana had allelochamicals they affected adversely the seed germination. Leaf extract found to be more inhibitory effect compared with fruit, flower and stem. Kumbhar and Patel (2013**)** [49] designed an experiment to examine the alelopathic effect of *Lantana camara* L. on hypocotyle and radical growth of wheat, green gram and pigeon pea. Significant inhibition of growth was observed. Pigeon pea was restrained in all concentration of water extract of lantana whereas hypocotyle growth of green gram was stimulated in 1% and 3% concentration compared with control. At higher concentration (5% and 10%) the radical growth of all crop inhibit significantly was found. Wheat species was intermediate in their growth response; pigeon pea was more sensitive and greener gram was least affected by water extract of lantana. Mishra (2013) [55] performed an experiment to evaluate the phtotoxic effect of lantana leaf extract on germination and growth of *Trigonella foenum-graceum* L. under laboratory condition. Allelochamicals play major role in influencing the crop productivity through stimulatory or inhibitory effect. Different concentration of lantana leaf extract 10%, 25 %, 50%, 75% and 100% showed inhibitory effect on germination, shoot and root elongation of *Trigonella foenum-graceum* L.

5. *Achyranthus aspera*

Alkari and Chaturvedi (2014) [3] concluded that phytochemical analysis of *Achyranthus aspera* L. had rich reservoir of different type of alkaloids, triterpenoid, diterpinoid, steroids, cardiac glycosides, polyphenols, sapogenins and seuiterpnen lactones. Alchohlic extract of leaf (28.98%) at 3hr and stem (35.17%) at 1hr show highest percentage inhibition in paw volume comparable to that of standard at 1hr. It has shown in-effective against *candida species* slight activity against *Aspergillus niger* and *verticillium* while moderate against *Fusarium oxysporium*. Acetone extract of *A. aspera* has inhibited the growth of *Staphylococcus aureus* (*Gram +ve*), *Escherichia coli* (*Gram –ve*). *Achyranthus aspera* is an effective anti-inflammatory agent and antibacterial agent for gram positive bacteria. *A.aspea* proves to be a rich reservoir of phytochemicals. Gupta and Narayan (2010) [31] conducted an experiment to investigate the effect of leaf biomass of *Parthenium hyterophorous* L., *Achyranthus aspera* L. and *Cassia obtusifolia* L. weeds on germination and seedling growth of pea and wheat and change in soil organic carbon. Soils were amended with leaf biomass of weeds and mixture of leaf biomass of *A. aspera* or *P. hysterophorous* (5 g/kg soil) with *C. obtusifolia*. Leaf biomass significantly influenced the crop growth and soil organic C pool. However, impact of crop specific depended on doses and quality of weed type (leaf biomass). The mixture of *P. hysterophorous* had variable effect. Geetha *et al.* (2010) [27] conducted an experiment to investigate the antimicrobial activity of *Achyranthus aspera* L. extract against the bacterial species *viz; S. aureus*, *Corynebacterium* sp., *Vibrio* sp., *Klebsiella* sp. and *Escherichia coli*. Ethanol extract (75µg/ml) was found maximum antibacterial activity against *E. aerogens* (19 mm) followed by *S. aureus* (14 mm), *Klebsiella* sp. (11 mm), *Corynebacterium* sp. (9 mm) and *Vibrio* sp. (7 mm). Hexane and aqueous extract of *A.aspera* show moderate antibacterial activity as compared to ethanol extract. Efficiency of *A.aspera* ethanol extract was found to be almost similar that of standard antibiotic like tetracycline (20µg/ml). Minimum inhibitory concentration of *A. aspera* ranged between 20-40 µg/ml for test pathogenic bacteria organisms. Beaulah *et al*. (2011) [7] conducted an experiment to evaluate the antioxidant and antibacterial activities of the *Achyranthes aspera* L. plant extract in different organic solvents. The radical scavenging activity of the different extracts of stem, leaf, inflorescences and root was evaluated by DPPH assay and the antibacterial activity against Escherichia coli a gram negative and Staphylococcus aureus gram positive bacterium was studied by Agar well cut diffusion method. All the extracts exhibited different antioxidant and antibacterial activities and activities varied from solvent to solvent and the activities are concentration and depends on time. The antioxidant and antibacterial activities were compared with the positive control Ascorbic acid and Gentamycin. Phytochemical analysis was carried out and found to possess bioactive compounds like alkaloids, tannins, steroids, terpenoids, flavonoids, glycosides.

6. *Withania somnifera*

Javaid *et al.* (2009) [37] conducted an experiment to determine the herbicidal effect of medicinal plant *Withania somnifera* and *Datura alba* nees against the *Rumex dentatus* L. one of the problematics weds of wheat in Pakistan result showed that germination of *Rumex dentatus* was less susceptible but root growth was highly susceptible to all aqueous extract. Application of extracts caused 68 percent reduction of germination, 62 percent shoot length, 96 percent in root length and 68 percent seedling biomass. The experiment was conducted to evaluate the allelopathic effect of hydroalcohlic extract of *Withania somnifera* L. on germination and radical growth of *Cicer arietinum* L. and *Triticum aestivum* L. seeds. The extract at different concentrations was incubated in controlled conditions with the surface sterilized seeds of *C. arietinum* and *T. aestivum* and observed periodically for seed germination and radicle growth to assess the allelopathic behavior. Extract of different concentration were applied mainly the higher concentration were showed significantly inhibit the seedling germination and radical elongation of testing species. *T. aestivum* was found to be a more sensitive compared with *Cicer arietinum* L. (Chandra *et al.*, 2012) [13]. Alam and Azmi (1989) [2] conducted an experiment to evaluate the inhibitory effect of *Withania somnifera* L., *Abutilon indicum* L., *Antigonon leptopus* L., *Prosopis glandulosa* L. against wheat cultivar. Results show there was no inhibitory effect of plants residues on seed germination. *P. glandulosa* residues show inhibitory effect on shoot and root growth. Root growth was more sensitive compared with shoot growth. *W.somnifera*, *A. leptopus* and *A. indicum* residues show similar inhibitory effect on seedling growth of *T.aestivum*. Javaid and Akhtar (2015) [37] conducted an experiment to evaluate the anti-fungal activity of *Withania somnifera* L. against *Fusarium oxysporum f. sp. Cepae*. Different concentration of methanolic root stem and fruit extract from 0.5 to 4% was used as treatment. Methanolic extract of root was further fractionated with *n*-hexane, chloroform, ethyl acetate and *n*-butanol. A range of concentrations of these extracts viz. 200, 100… 3.125 mg mL-1 were prepared and assessed for their antifungal activities. Methanolic root extract of *W. somnifera* significant inhibit the fungal activity, about 93% decreases in biomass of fungal pathogen. Root extract of *Withania somnifera* have potential to use as antifungal to control the *F. oxysporum f. sp. Cepae*. Javaid *et al*. (2009) [37] investigated that herbicidal activity of *Withania somnifera* L. against *Phalaris minor*. In laboratory the aqueous, *n*-hexane and methanol extract of different concentration were applied. The *n*-hexane extract of *W. somnifera* both shoot and root exhibited insignificantly or stimulatory effects against plant biomass and weed shoot length. Methanol extract show highest degree of toxicity, different concentration of methanol shoot and root extract decrease germination of *P.minor* and shoot and root length. The aqueous extracts show comparatively less toxic compared with methanol extracts. Highest concentration of aqueous extract shows 55% suppression of weed germination. In foliar spray bioassay, aqueous and methanol extract on one and two week old seedling of *P.minor*. The aqueous extract significantly reduced the root shoot dry biomass of one-week old *P. minor* plant. Residue incorporation bioassay show significantly inhibition against *P.minor*. Jeyanthi and Subramanian (2009) [39] investigated that the protective effect of *Withania somnifera*, an indigenous medicinal herb used in ayurvedic traditional system on gentamicin (GEN)-induced nephrotoxicity. The root extract of three different doses of *W. somnifera* (viz., 250, 500, and 750 mg/kg) was administered orally to rats for 14 days before GEN treatment and thereafter concurrently with GEN (100 mg/kg) for 8 days. Nephrotoxicity was evident in GEN-treated rats by significant increase in kidney weight, urea, creatinine, urinary protein, and glucose, and significant reduction in body weights and potassium, which was histopathologically confirmed by tubular necrosis. In contrast *W. somnifera* (500 mg/kg) significantly reversed these changes as evidenced microscopically when compared to other two doses of *W. somnifera* (250 and 750 mg/kg), and there were no significant changes in the levels of sodium in the experimental animals compared to control. Nephroprotective effect of *Withania somnifera*, which could be by enhancing antioxidant activity with natural antioxidants and scavenging the free radicals.

7. Conclusion

Waste-land weeds create problems during the crop seed germination and seedling growth. Aqueous extracts of *P. hysterophorous* and rhizospheric soil of *L. camara* were proved to be more phytotoxic against crops. The overall inhibitory effect of aqueous extract was more pronounced than by rhizospheric soils of weeds especially on germination and growth of crops. Among weeds, *P. hysterophorous* and *L. camara* were found to be highly allelopathic against crops especially. Among crops, *A. sative* more susceptible to the aqueous extracts and *T. aeastivum* more susceptible to the rhizospheric soils of weeds.

8. References

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