Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 3235-3240
Received: 25-05-2018
Accepted: 30-06-2018

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A study on crop weed competition in field crops

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Abstract
A weed is important biological factor in crop production that cause yield reduction and it contributes around 45% of crop yield loss. Weed life cycle similar with crops and some weeds have same morphological character with crop plants and farmers difficult to identify it at early crop growth stage. So the main concern of this review is to know critical time for crop weed competition, effect of weeds on plant growth and development, physiological changes, yield performance weeds studies includes density, different weed floras and its dry matter accumulation, finally why and purpose of weeds compete with crops. Increasing initial weed competition period reduces crop germination and at later stage of crop growth reduces the growth and development parameters like plant height, dry matter accumulation, leaf area index, physiological parameters like CGR, RGR, NAR, Chlorophyll content, leaf thickness are reduces. Similarly, increasing weeds competition reduces crop yield drastically.

Keywords: physiological, critical period, weed flora, dry matter, chlorophyll, competition, yield

Introduction
There are about 30,000 plant species identified as weeds. Among these, 250 are listed as very troublesome in crop production which is an important factor that causing major yield losses. In general, 45 per cent of yield loss caused by weeds (anonymous, 2010) if there is increase in weeds population in different field crops like in rice 69 per cent yield loss, 34 per cent in wheat, 50 per cent in pulses, 72 per cent in sugarcane and in almost all vegetables around 90 percent of yield will reduces. A large gap is noticed between the potential yield and the actual yield obtained and globally 287 tonnes of food loss due to weed infestation which accounts for 11.5 per cent of the total food production (Boopathi, 2010) [13].

Invasive weeds like terrorists and unless they were controlled, they could cause huge destruction and weeds were caused an annual loss of Rs.30,000 crore in India alone (Manjunath and Subbian, 2010) [68]. So that weed management is one of the important strategies for minimising the yield loss. Before taking management strategies we should know their biology like competition themselves and with crops. Weeds and crops are very similar in their life cycle for rooting, growth and development, efficient utilisation of resources available their surrounds. Both weeds and crops are competing for carbon-di-oxide and nitrogen from the atmosphere, water and minerals from the soil and light from the sun for their growth and development. As a result, growth of the crop plant is restricted and yields are drastically reduced. The yield losses due to weeds have been reported to vary from 16 to 68 per cent in cultivated crops under different agro-climatic conditions.

A concept of competition is the struggle for survival and continued for existence. In similar way crop weed competition is the relationship between two or more species in which supply of growth factor falls below their combined demand. The competition does not occur when the growth factor is abundant. However, it starts immediately when growth factors fall short in supply. In similar way, the critical period of weed competition might have originated from the belief that weeds are not equally damaging throughout the crop period. There may be a certain stages in crop growth period when weeds are more harmful to crop growth and yield. Because of its initial slow growth weeds are taking advantage to utilise more resources and dominate over crops. Mainly weeds compete with crop for nutrients, solar radiation, soil moisture etc. Weeds compete with crop whole life cycle but its effect does not remain same during all stage of crop growth. Therefore the short time span in the life cycle of crop growth, when weed causes maximum reduction in its yield or in other words, when weed control measure if adopted may fetch near maximal or maximum acceptable crop yield it is known as critical period of crop weed competition. It is therefore, simply the specific duration of weed free situation of a crop resulting into near maximal yield, which is sufficiently close to that obtained by the season long weed free situation.

Hence in this review brief on different weed flora, physiological changes of both crop and weeds, critical period crop-weed competitions and its difference competition resources with crop and weed finally their effect on growth and yield attributes of different field crops has been reviewed and highlighted under following heads:

Critical growth period of weed control

The critical period of weed control (CPWC) is the period of crop growth when the crop must be kept weed-free to prevent yield loss due to weed interference (Van Acker *et al*. 1993) [74]. The Critical period for weed competition is estimated from two factors, namely, (1) the critical weed-free period (CWFP) defined as the minimum duration of a weed-free period required following planting to prevent yield losses above 5% threshold and (2) the critical time of weed removal (CTWR), the maximum period of time a crop can be exposed to early season weed competition before it reached to threshold yield loss The CTWR and the CWFP delineate the beginning and end of the CPWC, respectively. Similarly, results shows in lentil crop the CPWC studies have been quite variable (Al-Thahabi *et al*., 1994; Erman *et al*. 2008; Mohamed *et al.* 1997; Singh *et al*. 1996) [4, 24, 48, 62, 65]. Hawtin *et al.* (1980) [31] showed that between 30 and 60 days after emergence (DAE), between 60 and 90 DAE and between 49 and 56 DAE (Al-Thahabi *et al*., 1994) [4] was the CPWC in lentil in India, Syria and Jordan, respectively. In similar way, Singh *et al*. (1996) [62, 65] estimated between 38 and 92 DAE in Jordan based on a 10% yield loss threshold and 5% yield loss threshold, is between 2 and 4 or 4 and 6 weeks after emergence depending on location (Mohamed *et al.*, 1997) [48] in Iran.

In western Iran Mashhadi and Ahmadi (1998) [42] estimated a CPWC of 27 to 44 DAE, between the 6 and 14 leaf stage, and 205 to 385 GDD. Al-Thahabi *et al.* (1994) [4] in Jordan estimated 35 to 49 DAE; Masood-Ali (1993) [43] and Ahlawat *et al*. (1981) [2] in India estimated 0 to 56 DAE and 28 to 56 DAE, respectively; and Saxena *et al*. (1976) [57] in India estimated that hand weeding at 30 and 60 DAE would prevent unacceptable yield loss from weeds.

Weeds effect on physiological parameters of crop

A competition between among and between the species which may strongly changes their physiological characteristics of growth and development. It leads to differences in the use of environmental resources, especially the water, which directly affects the availability of CO_2 in leaf mesophyll and leaf temperature therefore, the photosynthetic efficiency decreases (Procopio *et al*., 2004) [54]. According to Hakim *et al*. (2013) [30] the chlorophyll (chl) content (SPAD value) was decreased with increasing the duration of weed interference period. The maximum chl content (42.10) was observed in the season long weed-free treatment followed by 75 day weed-free and 30 day weedy treatments (>41) while the minimum chl content was found in the season-long weedy treatments. Chlorophyll is the main pigment of photosynthesis in plants. It is strongly influenced by environmental factors (Qiu *et al.*, 2007) [55]. Abdollahian and Williams (2005) [1] observed the significant reduction in leaf chlorophyll content in sugar beet from the competition with *Chenopodium album* and chlorophyll content became reduced with increasing weed competition and weeding durations are significantly influenced with chlorophyll content of cowpea (Olorunmaiye, 2010) [52].

Olayinka and Etejere (2015) [51] shown that the relative growth rate (RGR) was highest between 6 and 8 WAS in MK 373 and 8-10 WAS in Samnut 10 of two groundnut variety and declined with advent of time thus all the weed control treatments had higher RGR as compared to the weedy check.

Crop-weed competition

Crop weed competition indicates the competition between crops and weeds in natural eco-system in response to resources struggle for their existence and superiority. Mainly the crops and weeds are competing for sunlight, CO_2, soil moisture, nutrients, space etc. to complete their life cycle.
These points explained in following heads.

Competition for light

Under thick canopy light cannot be stored like water or nutrients and hence must be intercepted as and when it is available or else it will be lost forever. Weeds deplete Photosynthetically Active Radiation by shading of lower leaves. Taylor *et al.* (1982) [71] reported that the seed yield increased in narrow row to wide row cultured soybean and this attributed to greater light interception. Edward *et al.* (1985) [23] observed a linear relationship between weeds and soybean and showed that the variation accounts for 86 per cent due to shading by the weeds. It was predicated that 19 to 25 per cent yield loss was observed due to 44-56 per cent shading of the crop by the weeds. David *et al.* (1990) [20] reported that, soybean yield losses were highly correlated (r^2= 0.84) with leaf area of weeds as viewed from directly above the weed crop canopy. Further, they stated that after a week of soybean emergence, the weed canopy diameter measured from overhead photographs also correlated well with soybean losses (r^2 = 0.82), but correlation with actual leaf area of weed was not significant (r^2= 0.31) Berti and Sattin (1996) [9] was of the opinion that the competitive effect of the weeds appeared to strictly related to other relative cover, indicating that for weeds growing taller than crop, the main competitive factor may be the shading caused by the leaves of weeds situated above the canopy.

Competition for Nutrient

Safdar *et al.* (2016) [56] reported that Uptake of N, P and K by *parthenium* increased with increase in its competition period. This might be due to higher accumulation of dry biomass per unit area. Nitrogen, phosphorus and potassium uptake by *parthenium* was in the range of 2.7-18.4, 0.2-2.4 and 2.3-17.7 N, P and K kg ha^{-1}, respectively, at its different competition periods. *Parthenium* N uptake response to increasing density was quadratic during both experimental years. However, both the P and K uptakes showed a linear trend and quadratic trend during 2012 and 2013, respectively. Increase in NPK-uptake by *parthenium* with increasing crop-weed competition duration might be the result of greater plant biomass accumulation with prolongation in its growth period. Lindquist *et al*. (2007) [36] were also reported that N uptake by velvetleaf (*Abutilon theophrasti*), a broadleaf weed in maize increased significantly in linear as well as quadratic pattern by increase in competition period from 0 to 100 days after crop emergence.

Seyyedi *et al.* (2016) [58] indicated that N, P and K contents in black seed grains and tissues significantly decreased as the weed-black seed competition increased during WI periods. Overall, N, P and K contents in weed species tissue were found to be 1.8 to 2 times higher those that of black seed. A significant decrease in N, P and K contents in black seed tissue emphasize the poor absorption ability of nutrients by black seed in competition with weed species. Mehriya *et al.*

(2007) [46] observed high uptake of N, P and K by weeds under weed-cumin (*Cuminum cyminum*) competition. Kondap *et al.* (1985) [38] reported that weeds in groundnut crop accumulated 49.50, 8.49 and 59.47 kg N, P and K ha^{-1}, respectively, at harvest.

Competition for moisture

The competition for water occurs in below ground it is mainly depends on rooting pattern and their volume. For producing of equal amount of drymatter the weeds absorbs more moisture from soil than the crop. In pearl millet field the cynodon dactylon has twice the water transpiration than pearl millet because of its roots are more deeper in soil. In weedy field the moisture is more extracted by weeds and crops are at plants reaches active vegetation to reproduction stage. From water use efficiency point of view, most of weed species are C_4 type having higher WUE as compare to the C_3 type of crop species (Silva *et al.*, 2007) [59].

Effect of crop-weed competition on growth and yield attributes

Plant height

Hakim *et al*. (2013) [30] observed that rice plant height and weed competition period was significantly influenced by increased the length of weed interference were but there was no significant adverse effect after 45 DAT in weedy treatments. Azmi (1990) [5] pointed out that the plant height of rice decreased when weeds were allowed to compete till 30 DAT and up to harvest. Begum (2006) [8] observed that the plant height of rice significantly reduced when rice plant competed with *F. miliacea* up to 70 days or longer. Similarly, Chauhan and Johnson (2010) [16] noted that plant height of rice was significantly reduced by competition with wild rice (*Echinochloa colona*), and the reduction was increased in higher weed density. McGregor *et al.* (1988) [45] reported that rice plant height was significantly decreased with weed competition up to 40 days or longer. Seyyedi *et al.* (2016) [58] indicated that black seed height was strongly affected by different Weed Free (WF) and Weed Interference (WI) periods. Entire growing season of black seed in weed interference treatment caused to an increase in height by 30.3%, as compared with the WF throughout the growing season treatment. And higher weed height, especially *C. album*, *Echinocloa crussgalli* and *A. retroflexus* compared with black seed plants (approximately 1.2 to 2.6 times); therefore, probably there was more competition between black seed and weed community over light absorption.

Dry matter accumulation

The highest weed DM was found with season long weedy plots. The treatments where weeds were allowed to grow at the early stages (15 DAT) accumulated higher DM than those allowed to grow at the later stages of the crop growth in rice. The weeds emerging at the later growth stages offer less competition to crops as it accumulates lower DM (Uremis *et al.*, 2009) [72].

Leaf area index

Hakim *et al*. (2013) [30] reported that with increase in the length of weed interference period rice leaf area was adversely affected and, as compare to increasing span of weed free period, up to 30 DAT. The maximum leaf area was observed in the season-long weed-free treatments with 1185.6 cm^2 $hill^{-1}$, and gradually decreased in all the weedy treatments. Similarly, DM production in rice was decreased with the duration of weed competition. Season long weedy treatment produced lowest rice plant biomass due to a consequence of disturbance in mineral supply, lower water potential and nutrient uptake disturbance by weeds which resulted in reduced growth and lower rice leaf area. Effective weed control is necessary to enhance LAI of groundnut (Kumar, 2009) [40]. Singh (2003) [60] observed that in Sourashtra region of India, LAI of bunch varieties of groundnut might be 1.7 at 60 days after planting (DAP), and might increase to 4.0 at 90 DAP. According to McCloud (1974) [44], LAI of groundnut was reached 3.0 at 64 DAP, which at maturity (137 DAP) were reduces to 1.7. The reduction in LAI at 12 WAS in Samnut 10 and 10–12 WAS in MK 373 was due to pest attack (Banik *et al*., 2009). Reduces the corn leaf area with Weed interference by reducing the expanded leaf area of each individual leaf and accelerating senescence of lower leaves.

Yield performance

Bhalerao *et al*. (2011) [10] reported that the maximum value of yield attributes (*viz.*, total number of developed pods, hundred pod and hundred kernel, test weight, shelling percentage and volume weight) were observed in weed free treatment followed by two hand weeding and hoeing at 15 and 30 DAS and pre-emergence pendimethalin followed by one hand weeding at 30 DAS. Similarly, Olayinka and Etejere (2015) [51] observed the highest number of matured pods per plant, seed weight per plant, 100 seed weight, pod yield, seed yield and harvest index were recorded in rice straw mulch + one hand weeding at 6 WAS over all other treatments. Lowest yield components and yield were recorded in weedy check. Weed competition throughout the crop duration resulted in 100% yield loss in both rice cultivars compared to weed-free conditions, in which yield was 6.39-6.80 t ha^{-1} for cultivar PR 114 and 6.49-6.87 t ha^{-1} for PR 115 (Singh *et al*., 2014) [63]. Faryadras and Farnia **(**2014) [25] reported that, the weed free control had the highest ear weight (260 g), 1000 kernels weight (356.67 g), the number of kernels in ear (785.33), biological yield (56800 kg ha^{-1}) and grain yield (16660 kg ha^{-1}). The full season long weed competition treatment had the lowest ear weight (160 g), 1000 kernels weight (236.67 g), the number of kernels in ear (380.5) biological yield (27400 kg ha^{-1}), grain yield (5525 kg ha^{-1}) and the harvest index (20.36 %). The highest harvest index was achieved in weed control up to 10 days after emergence in maize.. In case of fababean grain yield and yield contributing traits were significantly affected by weed competition. Weed-crop competition may end at 45 days. Grain yield losses due to uncontrolled weed growth throughout the crop cycle were 46%. At the same time, plant height, numbers of pods per plant, numbers of seeds per pod and 1000 seed weight were significantly decreased due to weeds (Kavurmaci *et al.*, 2010) [35]. Singh *et al.*, (2016) [61] showed, yield attributes and grain yield declined with the increased duration of crop-weed interference period and increased with long weed free durations in spring maize.

The highest yield of groundnut pods (16.18 q ha^{-1}) and haulm (10.30 q ha^{-1}) were observed in weed free check. Reduction in crop yield had direct correlation with weed competition. In drought situation, weeds thrive better than crop plants. When left uncontrolled, weeds can grow taller than crop plants and suppress the crop growth. Yield reduction from 30 to 35 per cent due to the presence of weeds had been reported in groundnut (Chaugule and Khuspe, 1962; Kulkarni *et al.*, 1963 and Verma, 1964) [15, 39, 75]. The yield loss caused by weeds

was estimated at 30 to 50 per cent in groundnut (Dalal *et al*., 1967) [19]. Hill and Santleman (1969) [32] reported yield reductions as high as 90 to 95 per cent due to weeds depending on the type and density of weed flora.

Study on weeds

Increasing weeds population in specified area use to utilise more resources efficiently and build their growth and development and less availability to crops in same space. Weeds are grasses, broad leaved weeds and sedges are different competing ability with crops. For better weed management need to know the different weed floras, weed density and its dry matter holdings.

Weed flora

In general, around 40% of crop yield loss by weed infestation. It mainly depends on the type, species and density of weeds growing in a crop community, as weeds vary from place to place and season to season. Singh *et al*. (2014) [63] reported that dominant weed species in rice field during both years were *Cyperus rotundus* and *Cyperus compressus* among sedges; *Echinochloa crus-galli*, *Echinochloa colona*, *Dactyloctenium aegyptium*, *Digitaria ciliaris*, *Eragrostris spp*. among grass weeds; *Euphorbia hirta*, *Phyllanthus niruri*, *Trianthema portulacastrum*, *Ammannia baccifera* among broadleaved weeds. Similarly, *Rottboellia cochinchinensis*, *Digitaria ciliaris*, *Echinocloa colona*, and *Eleusine indica*. *Ageratum conyzoides*, *Amaranthus spinosus*, *A. viridis*, *Commelina benghalensis*, *Corchorus olitorius*, *Cyperus iria*, *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Eclipta prostrata*, *Portulaca oleracea*, and *Trianthema portulacastrum* were others species common during both seasons (Chauhan and Johnson., 2011) [17]. Mehrotra *et al*. (1984) [47] were reported that the major weeds associated with sunflower on sandy loam soils of Kanpur were, *Cyperus rotundus*, *Spergula arvensis*, *Anagallis arvensis*, *Melilotus* sp., *Convolvulus arvensis*, *Asphodelus tenuifolius*, *Launaea asplenifolia*, and *Chenopodium album.* Solunkhe *et al.* (1990) [66] reported that Dominant weeds associated with the sunflower crop were *Euphorbia* sp. *Amaranthus polygamous*, *Sonchus arvensis*, *Digera arvensis* and *Denebra* sp. Similarly, Bochare *et al.* (1992) [12] reported that *Dinebra retroflexa*, *Phyllanthus maderaspatensis*, *Digera arvensis*, *Acalypha indica* and *Cyperus rotundus* are the dominated weeds in sunflower field.

Weed Density and its dry matter production

Seyyedi *et al*. (2016) [58] observed that in black seed (*Nigella Sativa* L.) both years of the experiment, the highest weed densities were observed at 42 days after emergence and then declined. On 42 days after seedling emergence, total weed density was found to be higher in the first year (384 plants m^{-2}) than in the second year (312 plants m^{-2}). However, during both years, dominant weed species were very similar.

Safdar *et al*. (2016) [56] *parthenium* weed dry mass increased in a quadratic fashion with increase in its competition period. The higher dry biomasses (32.9 and 33 g m^{-2}) were gained by full crop season parthenium weed competition during years 2012 and 2013, respectively. The less *parthenium* weed dry biomasses (6 and 8.2 g m^{-2}) was recorded in plots with *parthenium* weed compete with maize up to 35 days after crop emergence (DAE) during 2012 and 2013. Increase in dry biomass of *parthenium* with extended competition duration was presumably attributed to prolonged growth span of weed ultimately resulting in more biomass accumulation.

Conclusion

Weeds are most dangerous terrorist which causes more yield losses. It influences on crop from germination to harvesting. Most of weed flora and its density cause higher losses during initial stages of crop growth. Increased weed competition period increases the competitive ability of both crop and weed while decrease the physiological aspects of growth and development and finally yield attributes and yield of a specified crop. Weed control at critical period of crop weed competition is economical and it reduces the cost of chemicals and time saving.

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