CROP-WEED ASSOCIATION, CROP-WEED COMPETITION AND ALLELOPATHY

Weeds posseses many growth characteristics and adaptations which enable them to exploit successfully the numerous ecological niches left unocccupied by crop cultures. Weeds compete with themselves and with crop plant. Among the more important adoptations relevent to competitive advantage are properly synchronized germination, rapid establishment and growth of seedlings, tolerance to shading effects by the crop or by other weeds at the time of establishment, quick response to available soil moisture and nutrients, adaptation to the most severe climatic situations of the habitat, adaptations to the edaphic regime, relative immunity to post seeding soil disturbance, practices and resistance to herbicides that are used. In the nitial stages of invasion by weeds of exposed ecological niches, only a very limited competition for resources by the crop and weed may occur, but as establishment of the crop-weed association is completed, competition for the available reources is more obvious.

Plant competition is a natural force whereby crop and weed plants tend to attain a maximum combined growth and yield, with the development of each species being to some extent at the expense of the other. It occurs when the demands of the plants for moisture, nutrients, light, and possibly carbon dioxide exceed the available supply. Competition may develop between crop and weed plants and also between individual plants of each. The ultimate outcome of competition usually results in the development of a characteristic crop-weed association. Crop plants and weeds may grow and mature in the state of mutual supression that is often found in crops where no suitable herbicide is available to control the weeds. The weed suppresses the crop and result in reduction of yield. The crop also suppresses the weeds, a condition often found in row crop cultures. This is a logical sequence in a crop habitat where both cultural and herbicide methods provide effective control.

A principle of plant competition is that the first plants to occupy an area have an advantage over latecomers. This principle is of foremost consideration in practical weed control, where cropping practices are always directed to the establishment of the crop ahead of the weeds.

Competition and allelopathy are the main interactions, which are of importance between crop and weed. Allelopathy is distinguished from competition because it depends on a chemical compound being added to the environment while competition involves removal or reduction of an essential factor or factors from the environment, which would have been otherwise utilized.

CROP WEED COMPETITION

Weeds appear much more adapted to agro-ecosystems than our crop plants. Without interference by man, weeds would easily wipe out the crop plants. This is because of their competition for nutrients, moisture, light and space which are the principle factors of production of crop. Generally, an increase in on kilogram of weed growth will decrease one kilogram of crop growth.

1. Competition for Nutrients

Weeds usually absorb mineral nutrients faster than many crop plants and accumulate them in their tissues in relatively larger amounts.

- *Amaranthus* sp. accumulate over 3% N on dry weight basis and are termed as "nitrophills".
- *Achyranths aspera*, a 'P' accumulator with over 1.5% P_2O_5
- *Chenopodium* sp & *Portulaca* sp. are 'K' lovers with over 1.3% K_2O in dry matter

Mineral composition of certain common weeds on dry matter basis

S.No	**Species**	**N**	**P_2O_5**	**K_2O**
1.	*Achyranthus aspera*	2.21	1.63	1.32
2.	*Amaranthus viridis*	3.16	0.06	4.51
3.	*Chenapodium album*	2.59	0.37	4.34
4.	*Cynodon dactylan*	1.72	0.25	1.75
5.	*Cyperus rotundus*	2.17	0.26	2.73
Crop plants				
1.	Rice	1.13	0.34	1.10
2.	Sugarcane	0.33	0.19	0.67
3.	Wheat	1.33	0.59	1.44

- ✓ The associated weed is responsive to nitrogen and it utilizes more of the applied 'N' than the crop. Eg. The 'N' uptake by *Echinochloa crusgalli* is more than rice.
- ✓ Nutrient removal by weeds leads to huge loss of nutrients in each crop season, which is often twice that of crop plants. For instance at early stages of maize cultivation, the weeds found to remove 9 times more of N, 10 times more of P and 7 times more of K.

2. Competition for moisture

- ➢ In general, for producing equal amounts of dry matter, weeds transpire more water than do most of our crop plants. It becomes increasingly critical with increasing soil moisture stress, as found in arid and semi-arid areas.

- As a rule, C_4 plants utilize water more efficiently resulting in more biomass per unit of water. *Cynodon dactylon* had almost twice as high transpiration rate as pearl millet.
- In weedy fields soil moisture may be exhausted by the time the crop reaches the fruiting stage, i.e. the peak consumptive use period of the crop, causing significant loss in crop yields.

3. Competition for light

- It may commence very early in the cop season if a dense weed growth smothers the crop seedlings.
- It becomes important element of crop-weed competition when moisture and nutrients are plentiful.
- In dry land agriculture in years of normal rainfall the crop-weed competition is limited to nitrogen and light.
- Unlike competition for nutrients and moisture once weeds shade a crop plant, increased light intensity cannot benefit it.

4. Competition for space (CO_2)

Crop-weed competition for space is the requirement for CO_2 and the competition may occur under extremely crowded plant community condition. A more efficient utilization of CO_2 by C_4 type weeds may contribute to their rapid growth over C_3 type of crops.

ALLELOPATHY

Allelopathy is the detrimental effects of chemicals or exudates produced by one (living) plant species on the germination, growth or development of another plant species (or even microorganisms) sharing the same habitat.

Allelopathy does not form any aspect of crop-weed competition, rather, it causes Crop-Weed interference, it includes competition as well as possible allelopathy.

Allelo chemicals are produced by plants as end products, by-products and metabolites liberalised from the plants; they belong to phenolic acids, flavanoides, and other aromatic compounds viz., terpenoids, steroids, alkaloids and organic cyanides.

Allelopathic Effect of Weeds on Crops

(1) Maize

- Leaves & inflorescence of *Parthenium* sp. affect the germination and seedling growth
- Tubers of *Cyperus esculentus* affect the dry matter production

(2) Sorghum

- Stem of *Solanum* affects germination and seedling growth
- Leaves and inflorescence of *Parthenium* affect germination and seedling growth

(3) Wheat

- Seeds of wild oat affect germination and early seedling growth
- Leaves of *Parthenium* affects general growth
- Tubers of *C. rotundus* affect dry matter production
- Green and dried leaves of *Argemone mexicana* affect germination & seedling growth

(4) Sunflower

- Seeds of *Datura* affect germination & growth

Allelopathic Effect of crop plants on weeds

(i) Root exudation of maize inhibits the growth of *Chenopodium album*

(ii) The cold water extracts of wheat straw when applied to weeds reduce germination and growth of *Abutilon* sp.

Allelopathic effect of weeds on weeds

- Extract of leaf leachate of decaying leaves of *Polygonum* contains flavonoides which are toxic to germination, root and hypocotyls growth of weeds like *Amaranthus spinosus*
- Inhibitor secreted by decaying rhizomes of *Sorghum halepense* affect the growth of *Digitaria sanguinalis* and *Amaranthus* sp.

Factors influencing allelopathy

a. Plant factors

i. Plant density: Higher the crop density the lesser will be the allelo chemicals it encounters
ii. Life cycle: If weed emerges later there will be less problem of allelochemicals
iii. Plant age: The release of allelochemicals occurs only at critical stage. For eg. in case of *Parthenium*, allelopathy occurs during its rosette & flowering stage.
iv. Plant habit: The allelopathic interference is higher in perennial weeds.
v. Plant habitat: Cultivated soil has higher values of allelopathy than uncultivated soil.

b. Climatic factors: The soil & air temperature as well as soil moisture influence the allelo chemicals potential

c. Soil factors: Physico-chemical and biological properties influence the presence of allelochemicals.

d. Stress factors: Abiotic and Biotic stresses may also influence the activity of allelochemcals

Mechanism of action of allelochemicals

- Interfere with cell elongation
- Interfere with photosynthesis
- Interfere with respiration
- Interfere with mineral ion uptake

- Interfere with protein and nucleic acid metabolism

Use of Allelopathy in biological control of weeds:

1. Use of cover crop for biological control
2. Use of alleopathic chemicals as bio-herbicides

Effect of weed competition on crop growth and yield

1. Crop growth and yield is affected
2. Crop suffers from nutritional deficiency
3. Leaf area development is reduced
4. Yield attributes will be lowered
5. Reduce the water use by the crop
6. Affect the dry matter production
7. Lowers the input response
8. Causes yield reduction
9. Pest and disease incidence will be more

Losses Caused by Weeds

A. Reduction in crop yield

Weeds compete with crop plants for nutrients, soil moisture, space and sunlight. In general an increase in one kilogram weed growth corresponds to reduction in one kilogram of crop growth. Depending on type of weed, intensity of infestation, period of infestation, the ability of crop to compete and climatic conditions the loss varies. The table below depicts the percentage range of yield loss due to weeds in some important field crops.

Table1.1.Yield losses due to weeds in some important crops

Crop	Yield loss range (%)	Crop	Yield loss range (%)
Rice	9.1 – 51.4	Sugarcane	14.1 – 71.7
Wheat	6.3 – 34.8	Linseed	30.9 – 39.1
Maize	29.5 – 74.0	Cotton	20.7 – 61.0
Millets	6.2 – 81.9	Carrot	70.2 – 78.0
Groundnut	29.7 – 32.9	Peas	25.3 – 35.5

Among the pests weeds account for 45 % reduction in yield while the insects 30%, diseases 20% and other pests 5%.

B. Loss in crop quality

If a crop contains weed seeds it is to be rejected, especially when the crop is grown for seed. For example, the wild oat weed seeds are similar in size and shape of the crops like

barley, wheat, and its admixture may lead to rejection for seed purpose. Contamination by poisonous weed seeds is unacceptable and increases costs of crop cleaning. The leafy vegetables much suffers due to weed problem as the leafy weed mixture spoil the economic value.

C. Weeds as reservoirs of pests and diseases

Weeds form a part of community of organisms in a given area. Consequently, they are food sources for some animals, and are themselves susceptible to many pests and diseases. However, because of their close association with crop they may serve as important reservoirs or alternate host of pests and diseases.

D. Interference in crop handling

Some weeds can make the operation of agricultural machinery more difficult, more costly and even impossible. Heavy infestation of *Cynadon dactylon* causes poor ploughing performance.

E. Reduction in land value

Heavy infestation by perennial weeds could make the land unsuitable are less suitable for cultivation resulting in loss in its monetary value. Thousands of hectare of cultivable area in rice growing regions of India have been abandoned or not being regularly cultivated due to severe infestation of nutgrass (*Cyperus rotundus*) and other perennial grasses.

F. Limitation of crop choice

When certain weeds are heavily infested, it will limit the growth of a particular crop. The high infestation of parasitic weeds such as *Striga lutea* may limit the growing of sorghum or sugarcane.

G. Loss of human efficiency

Weeds reduce human efficiency through physical discomfort caused by allergies and poisoning. Weeds such as congress weed (*Parthenium hysterophorus*) causes itching. Thorny weeds like *Solanum* spp. restrict moment of farm workers in carrying out farm practices such as fertilizer application, insect and disease control measures, irrigation, harvesting etc.

H. Problems due to aquatic weeds

The aquatic weeds that grow along the irrigation canals, channels and streams restricts the flow of water. Weed obstruction cause reduction in velocity of flow and increases stagnation of water and may lead to high siltation and reduced carrying capacity. Aquatic weeds form breeding grounds for obnoxious insects like mosquitoes. They reduce recreational value by interfering with fishing, swimming, boating, hunting and navigation on streams and canals.

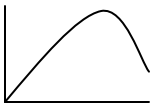
I. Other problems

Weeds are troublesome not only in crop plants but also in play grounds and road sides etc. *Alternanthera echinata* and *Tribulus terrestris* occurs in many of the playgrounds causing annoyance to players and spectators.

Factors affecting the competitive ability of crops against weeds

a. Density of weeds

Increase in density of weed decrease in yield is a normal phenomena. However, it is not linear as few weeds do not affect the yields so much as other weed does and hence, it is a sigmoidal relationship.



b. Crop density

Increase in plant population decreases weed growth and reduce competition until they are self competitive. Crop density and rectangularity are very important in determining the quantum and quality of crop environment available for the growth of weeds. Wide row spacing with simultaneous high, intra-row crop plant population may induce dense weed growth. In this respect, square planting of crops in which there are equal row and plant spacing should be ideal in reducing intra-crop plant competition.

c. Type of weeds species

The type of weeds that occur in a particular crop influences the competition. Occurrence of a particular species of weed greatly influences the competition between the crop & weed. For eg. *E. crusgalli* in rice, *Setaria viridis* in corn and *Xanthium* sp. in soybean affects the crop yield. Flavaria australasica offers more competition than the grasses

d. Type of crop species and their varieties

Crops and their varieties differ in their competing ability with weeds e.g., the decreasing order of weed competing ability is as: barley, rye, wheat and oat. High tolerance of barley to competition from weeds is assigned to its ability to develop more roots that are extensive during initial three weeks growth period than the others.

Fast canopy forming and tall crops suffer less from weed competition than the slow growing and short stature & crops. Dwarf and semi-dwarf varieties of crops are usually more susceptible to competition from weeds than the tall varieties became they grow slowly and initial stage. In addition, their short stature covers the weeds less effectively. When we compare the crop-weed competition between two varieties of groundnut TMV 2 (Bunch) and TMV 3 (Spreading), TMV 2 incurred a loss of over 30% pod yield under uncontrolled weed - crop

competition while TMV 3 lost only about 15% in its yield. The main reason is due to the spreading nature of TMV 3, which smothered weeds. Longer duration cultivars of rice have been found more competitive to weeds than the short duration ones.

e. Soil factors

Soil type, soil fertility, soil moisture and soil reaction influences the crop weed competition. Elevated soil fertility usually stimulates weeds more than the crop, reducing thus crop yields. Fertilizer application of weedy crop could increase crop yields to a much lower level than the yield increase obtained when a weed free crop is applied with fertilizer.

Weeds are adapted to grow well and compete with crops, in both moisture stress and ample moisture conditions. Removal of an intense moisture stress may thus benefit crops more than the weeds leading to increased yields. If the weeds were already present at the time of irrigation, they would grow so luxuriantly as to completely over power the crops. If the crop in irrigated after it has grown 15 cm or more in a weed free environment irrigation could hasten closing in of crop rows, thus suppressing weeds.

Abnormal soil reactions often aggravate weed competition. It is therefore specific weed species suited to different soil reactions exist with us, our crops grow best only in a specified range of soil pH. Weeds would offer more intense competition to crops on normal pH soils than on normal pH soils.

f. Climate

Adverse weather condition, Eg. drought, excessive rains, extremes of temperature, will favour weeds since most of our crop plants are susceptible to climatic stresses. It is further intensified when crop cultivation is stratified over marginal lands. All such stresses weaken crops inherent capacity to fight weeds.

g. Time of germination

In general, when the time of germination of crop coincides with the emergence of first flush of weeds, it leads to intense Crop-Weed interference. Sugarcane takes about one month to complete its germination phase while weeds require very less time to complete its germination.

Weed seeds germinate most readily from 1.25 cm of soil and few weeds can germinate even from 15cm depth. Therefore, planting method that dries the top 3 to 5 cm of soil rapidly enough to deny weed seeds opportunity to absorb moisture for their germination usually postpones weed emergence until the first irrigation. By this time the crop plants are well established to compete with late germinating weeds.

h. Cropping practices

Cropping practices, such as method of planting crops, crop density and geometry and crop species and varieties have pronounced effects on Crop-Weed interference.

i. Crop maturity

Maturity of the crop is yet another factor which affects competition between weeds & crop. As the age of the crop increases, the competition for weeds decreases due to its good establishment. Timely weeding in the early growth stages of the crop enhances the yield significantly.

Critical period of weed competition

Critical period of weed competition is defined as the shortest time span during the crop growth when weeding results in highest Economic returns.

The critical period of crop-weed competition is the period from the time of sowing up to, which the crop is to be maintained in a weed free environment to get the highest economical yield. The weed competition in crop field is invariably severe in early stages of crop than at later stages. Generally in a crop of 100 days duration, the first 35 days after sowing should be maintained in a weed free condition. There is no need to attempt for a weed free condition throughout the life period of the crop, as it will entail unnecessary additional expenditure without proportionate increase in yield. Critical period of weed competition for important crops ae as follows

S.No.	Crops	Days from sowing	S.No.		Days from sowing
1.	Rice (Lowland)	35	7.	Cotton	35
2.	Rice (upland)	60	8.	Sugarcane	90
3.	Sorghum	30	9.	Groundnut	45
4.	Finger millet	15	10.	Soybean	45
5.	Pearl millet	35	11.	Onion	60
6.	Maize	30	12.	Tomato	30

It becomes clear that weed free condition for 2-8 weeks in general are required for different crops and emphasizes the need for timely weed control without which the crop yield gets drastically reduced.