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Weed Growth Curve and their Role in Precision Weed Management

Balbir Singh Dogra, *Anjali Kumari and Shivali Dhiman
Department of Vegetable Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh), India
***Corresponding Author's email: anjalidrungal0055@gmail.com**

Weed competition severely affects vegetable crop growth, yield and quality due to early and rapid weed establishment and competition for essential resources such as nutrients, water, light and space. Vegetables are particularly vulnerable during early growth stages, when weeds often enter their exponential growth phase. Understanding the weed growth curve is essential for identifying periods of maximum crop–weed competition and for timely implementation of weed control measures. Effective management of weeds before their rapid growth phase reduces competition, prevents weed seed production, conserves resources for the crop and enhances productivity. Thus, weed growth curve–based weed management is vital for sustainable and profitable vegetable production.

Introduction

Weed competition in vegetable crops is a major constraint to productivity because weeds and crops demand the same limited resources such as light, water, nutrients, and space during their growth period. In vegetables, which are generally short-duration and slow-growing during early stages, weeds often establish earlier and grow faster, leading to severe competition during the initial growth phase. This competition reduces crop vigour, delays flowering and fruiting, lowers yield and deteriorates quality, especially in high-value vegetables like onion, tomato, brinjal and leafy greens. If weeds are not controlled at the right time, they dominate the crop canopy, absorb a major share of nutrients and moisture and ultimately cause substantial economic losses.

The weed growth curve plays a crucial role in preventing weed competition by helping to identify the period when weeds grow most aggressively and compete intensely with the crop. Since weed growth follows a sigmoid pattern, the early log (exponential) phase represents the stage of maximum competition. By understanding this growth pattern, weed control measures can be timed to eliminate weeds before they enter this critical phase, thereby protecting the vegetable crop during its most sensitive growth period. Timely intervention based on the weed growth curve not only reduces crop–weed competition but also prevents weed seed production, minimizes future infestations and ensures efficient use of resources by the crop, resulting in higher yield and better-quality produce.

Concept of Weed Growth Curve

A weed growth curve represents the pattern of weed emergence, growth, biomass accumulation and reproduction over time in relation to crop growth stages. Generally, weed growth follows a sigmoid (S-shaped) curve, comprising:

1. Lag phase – slow initial growth after emergence
2. Log (exponential) phase – rapid increase in weed population and biomass
3. Plateau phase – growth slows as weeds mature and resources become limiting

Understanding this curve helps identify periods of maximum competition between weeds and vegetable

Importance with Respect to Vegetable Crops

Identification of Critical Period of Weed Competition (CPWC)

Vegetable crops are high-value and short-duration, making them highly sensitive to early weed competition. The weed growth curve helps identify the critical period of weed competition, i.e., the time during which weeds must be controlled to prevent significant yield loss.

Vegetable Crop	Critical Period of Weed Competition
Okra	15–40 days after sowing
Cabbage	20-40 days after transplanting
Cauliflower	20-40 days after transplanting
Brinjal (Eggplant)	20–60 days after transplanting
Carrot	15-45 days after sowing
Turnip	15–20 days after sowing
Radish	25–30 days after sowing
Cucumber	First 4 weeks after seeding
Peas	20-40 days after sowing
Lettuce	First 3 weeks after sowing
Onion	Entire growing season
Chilli (Pepper)	20-40 days after transplanting
Potato	15–45 days after sowing
Tomato	20-45 days after transplanting

Weed growth curve analysis shows that weeds enter the log phase when vegetables are still in early vegetative stages, leading to severe competition.

Efficient Resource Utilization by Vegetables

Weeds and vegetables compete for light, nutrients, water and space. The weed growth curve indicates when weeds begin to accumulate biomass rapidly and outcompete vegetables for resources.

- Early weed growth reduces nutrient uptake by vegetables, especially nitrogen and phosphorus.
- Leafy and shallow-rooted vegetables (spinach, coriander, onion) are particularly vulnerable during early growth.

Protection of Yield and Quality

Vegetable yield and market quality are directly linked to early vigor and uninterrupted growth.

- Weeds growing rapidly during flowering or fruit initiation stages cause reduced fruit size, number, and uniformity.
- In root and tuber vegetables (carrot, radish, potato), weeds interfere with root expansion and shape, lowering market value.

Importance with Respect to Weeds

Understanding Weed Emergence and Dominance

Weed growth curves differ among species:

- Annual weeds show rapid early growth (e.g., *Amaranthus*, *Chenopodium*).
- Perennial weeds have slower initial growth but prolonged persistence (e.g., *Cyperus rotundus*).

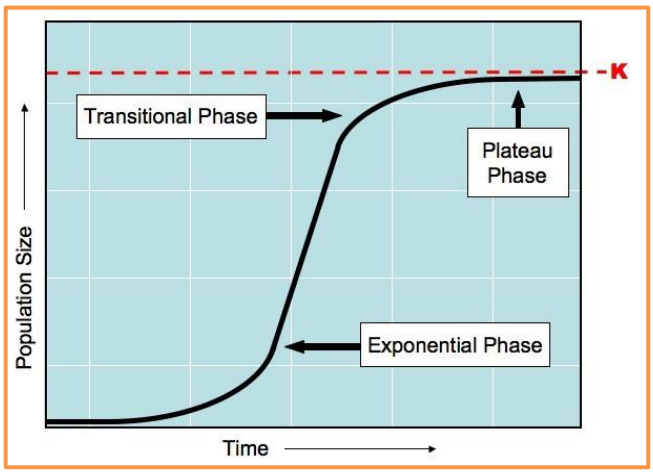
Studying weed growth curves helps predict:

- Time of emergence

- Peak competitive phase
- Reproductive stage

Timing of Weed Control Measures

Weed growth in vegetable fields follows a sigmoid (S-shaped) growth curve, similar to crop growth. Understanding this curve helps in timing weed control measures effectively, especially because vegetables are short-duration and sensitive to early weed competition.



Lag phase

- The lag phase represents the initial stage of weed growth immediately after germination, during which weeds exhibit slow growth due to limited leaf area, underdeveloped root systems, and low biomass accumulation.
- Effective weed control during the lag phase prevents weeds from entering the rapid growth phase and protects vegetables from early-season competition, which is crucial because yield losses initiated at this stage are often irreversible.
- Weed management during the lag phase is most effective and economical, as weeds are highly susceptible to control measures. Cultural and chemical methods such as stale seedbed technique in carrot, pre-emergence application of pendimethalin in tomato, okra and cabbage, use of plastic or organic mulches in cucurbits, and shallow hoeing or hand weeding are highly successful at this stage.

Log phase

- The log phase is characterized by rapid and exponential weed growth, marked by vigorous vegetative development, increased leaf area, extensive root proliferation, and maximum resource uptake.
- This phase coincides with the critical period of weed competition in most vegetable crops and is responsible for the highest yield reductions if weeds are not controlled.
- Weed management during this phase becomes more difficult and costly because weeds are larger and more tolerant to control measures.
- Integrated weed management practices such as post-emergence herbicides, inter-cultivation, hand weeding at critical intervals, and earthing up in cole crops are commonly adopted.
- Failure to control weeds during this phase results in severe and often permanent yield penalties, making timely intervention essential.

Stationary phase

- The stationary phase marks the stage when weed growth slows or ceases due to completion of vegetative development, and weeds enter reproductive stages such as flowering and seed formation.
- By this stage, weed biomass reaches its maximum, and although competition with vegetable crops declines, the damage in terms of yield loss has already occurred.
- Weed management during the stationary phase is therefore focused not on yield protection but on preventing weed seed production and future infestations.
- Practices such as rouging, cutting or uprooting weeds before seed set, field sanitation, and crop rotation are emphasized. Although chemical control is generally uneconomical at this stage, mechanical removal of flowering weeds is essential to reduce weed pressure in subsequent vegetable crops.
- Weed control is most effective when applied before or during the early log phase of weed growth.
  - Mechanical weeding is effective during early stages.

- Herbicides are most efficient when weeds are young and actively growing.

Prevention of Weed Seed Bank Build-up

The plateau phase of the weed growth curve corresponds to flowering and seed set.

- If weeds are allowed to reach this stage, they replenish the soil weed seed bank, leading to future infestations.
- In vegetables, repeated cropping cycles make seed bank management crucial.

Role in Integrated Weed Management (IWM) in Vegetables

Weed growth curve knowledge forms the backbone of Integrated Weed Management, allowing the integration of:

- Cultural methods (mulching, closer spacing, crop rotation)
- Mechanical methods (hand weeding, hoeing at critical stages)
- Chemical methods (pre- and post-emergence herbicides)
- Biological methods (cover crops, allelopathic mulches)

Economic and Environmental Significance

- Reduces unnecessary herbicide applications
- Minimizes crop injury and environmental pollution
- Improves cost–benefit ratio in vegetable production
- Enhances sustainability of intensive vegetable systems

Conclusion

The weed growth curve is a vital decision-making tool in vegetable weed management. By understanding weed growth dynamics in relation to vegetable crop growth, farmers and researchers can identify critical competition periods, optimize control measures, protect yield, quality and prevent weed seed bank buildup. Thus, weed growth curve-based management is essential for efficient, sustainable and profitable vegetable production.