WEED MANAGEMENT PRACTICES FOR COTTON - A REVIEW
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ABSTRACT
Cotton crop is slow in its initial growth and grown with wide spacing is subjected to severe weed competition during early stage that results in low yield. A wide spectrum of weeds with wider adaptability to extremities of climatic, edaphic and biotic stresses are infesting the cotton fields. High persistence nature of weeds is attributed to their ability of high seed production and seed viability. Hand weeding /Hoeing twice is the most commonly adopted method of weed control in cotton. However, complete weed control cannot be achieved by using any single method alone. Herbicidal weed control is a competitive and promising way to control weeds at initial stages of crop growth. Fluchloralin 1.0 kg ha⁻¹(PPI), Pendimethalin 1.5 kg ha⁻¹(PRE), Diuron (PRE - 1.125 kg ha⁻¹ and PO-0.75 kg ha⁻¹) were some of the effective herbicides in cotton. Effective weed control and highest seed cotton yield is obtained when herbicides were combined with hand weeding/hoeing than either practice was used alone. Integration of weed management practices not only boost the productivity but also help in the sustainability. Maintaining weed free period upto 60 days after sowing(DAS) is more remunerative and essential to obtain higher yield in cotton.

India is the largest cotton producer after China and USA with a production of 176.5 lakh bales from 91.66 lakh ha (Bardhan, 1998). India needs to produce about 23 million bales by 2010 AD to meet the anticipated domestic and export requirements. Due to population pressure and pressure from food crops, expansion in area beyond the present 9.0 ha is not feasible. The area under irrigated cotton is foreseen to be around 40% of total cotton area in 2010 AD (Gurumoorthy, 1998). Cotton is being cultivated in about 33 m ha in about eighty countries. India has the largest cotton growing area in the world. Besides, it is the third largest producer and second largest consumer of cotton (Gurumoorthy, 1998).

Role of cotton in national economy
The share of cotton in world textile production is 45 per cent and its production, processing and marketing provides employment to around 250 million people. The importance of cotton in the country’s economy is summarised in Table 1.

Table 1. Role of cotton in Indian economy (Kairon and Venugopalan, 2000)

<table>
<thead>
<tr>
<th>Area under cotton</th>
<th>9.2 m. ha (5% of the cultivated area)</th>
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<tbody>
<tr>
<td>Cloth production</td>
<td>35560 sq.m.</td>
</tr>
<tr>
<td>Production of cotton</td>
<td>16.87 million bales</td>
</tr>
<tr>
<td>Value of cotton</td>
<td></td>
</tr>
<tr>
<td>1. Textiles exported</td>
<td>386650 million rupees</td>
</tr>
<tr>
<td>2. Cotton based textiles exported</td>
<td>282250 million rupees (73%)</td>
</tr>
<tr>
<td>Employment sustained</td>
<td>60 million</td>
</tr>
<tr>
<td>Employment/ha</td>
<td>200 man days</td>
</tr>
<tr>
<td>Cotton seed oil produced</td>
<td>0.45-0.47 million tonnes</td>
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About 60 million people are employed in the production, processing and promotion of cotton. The textile industry provides employment to about 1.04 million people and around 1.0 million people are employed in powerloom and handloom sector. Cotton accounts for 55-60% of the textiles produced in India. A strong and vibrant pesticide industry
thrive largely on cotton which consumes about 30-32 thousand tonnes (which is about 55% of the total pesticides consumed).

Cotton production projection for the next decade

The projection of cotton requirements for the next decade and beyond depends upon the rate of growth of population, per capita income which decides the purchasing power, clothing habits, likely changes in processing technologies, fibre spectra required, competition from manmade fibres, demand from handloom, powerloom and small scale sectors, export demand and market prices for raw cotton, yarn and finished goods. Assuming a 3% rate of increase in cotton consumption by domestic sector and other projections given in Table 2, the total requirement of the country would be about 23 million bales in 2010 AD. This includes non-mill consumption of 1.2 million bales and an export quota of 1.0 million bales (11).

Table 2. Present and projected scenario (Kairon and Venugopalan, 2000)

<table>
<thead>
<tr>
<th></th>
<th>2000 A.D</th>
<th>2010 A.D</th>
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<tbody>
<tr>
<td>Population (million)</td>
<td>1000</td>
<td>1120</td>
</tr>
<tr>
<td>Area (million ha)</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Production (million bales)</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Productivity</td>
<td>340</td>
<td>434</td>
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</table>

Cotton, being an indeterminate plant grown with wider crop geometry that permits sufficient light to reach soil permits wide range of weeds to grow and compete with crop all through the season and cause greater yield losses. Yield loss in cotton have been estimated up to 92% per cent and above due to prolonged weed infestation.

WEED SPECTRUM IN COTTON

Study on weed flora of cotton by Balasubramanian and Sankaran (1976) indicated that *Cyperus esculentus* (L.), *Dactyloctenium aegyptium* (Beauv.) and *Cynodon dactylon* (L.) pers. were the prominent weeds among monocots and *Trianthema portulacastrum* (L.), *Digera arvensis* (Forsk.), *Flaveria australasia* (Hook.), *Gynandropsis pentaphylla* (DC.), *Datura fastuosa* (L.) and *Corchorus olitorius* (L.) were predominant among dicot weeds. Balasubramanian (1985) reported that *Trianthema portulacastrum* (L.), *Dactyloctenium aegyptium* (Beauv.), *Echinochloa colona* (L.) Link., *Cyperus rotundus* (L.), *Echinochloa crus-galli* (L.) P. Beauv., *Paspalum dilatum* (Poir.), *Corchorus* sp. and *Boerhaavia diffusa* (L.) were the major weed flora of rice fallow cotton in summer. Singh and Malik (1993) observed that *Trianthema portulacastrum* (L.) was the most dominant weed and other important weeds were *Echinochloa colona* (L.) Link., *Cyperus rotundus* (L.), *Digera arvensis* (Forsk.), *Phyllanthus niruri* (L.), *Celosia argentea* (L.) and *Physalis minima* (L.) in sandy loam soils of subtropics in cotton. Chander et al. (1994) and Panwar et al. (1995) also observed *Trianthema portulacastrum* (L.) and *Echinochloa crus-galli* (L.) P. Beauv. were the dominant weeds of cotton fields in sandy loam soil at Hisar. *Digera arvensis* (Forsk.), *Abutilon indicum* (G.) Don., *Dinebra retrarae* (Vahl.) Panzer., *Parthenium*
**hysterophorus** (L.) and *Cyperus rotundus* (L.) were reported by Jadhav *et al.* (1995) in rainfed cotton.

Though diverse weed species were reported in cotton crop, some weeds species are consistently reported over space and time. They are *Trianthema portulacastrum* (L.) (Brar *et al.*, 1995; Thind *et al.*, 1995; Ponnusamy and Kandasamy, 1996; Panwar *et al.*, 1997), *Cyperus rotundus* (L.) (Brar *et al.*, 1995; Thind *et al.*, 1995; Giri and Bhosle, 1997), *Cynodon dactylon* (L.) (Dadari *et al.*, 1994; Ponnusamy and Kandasamy, 1996; Rajeswari and Charyulu, 1996), *Digera arvensis* (Forsk.), *Euphorbia hirta* (L.) and *Acalypha indica* (L.) (Giri and Bhosle, 1997; Giri *et al.*, 1998) and *Dactyloctenium aegyptium* (L.) (Rajeswari and Charyulu, 1996; Rout and Satapathy, 1998) under various climatic and soil conditions in the country.

**CROP-WEED COMPETITION IN COTTON**

Weeds that grow in association with crop compete for nutrients, moisture, light and space, thereby affect the crop growth and result in lower yields (Moolani and Bachan, 1966). Weeds primarily compete for nutrient, moisture and sunlight in the early stage than in the later stage (Prentice, 1971). In general, competition between crop and weeds was more severe when the competing plants have similar vegetative habits and demands same resources (Rao, 1983). Weeds germinated in a thick stand with cotton seedling in the proportion of 30 to 50 weeds to one cotton seedling resulted in the stunted crop growth as well as delayed maturity of crop (Singh, 1983). A heavily shaded cotton plant suffers from reduced photosynthesis leading to poor growth, a smaller root system, and ultimately reduced capacity for water and nutrient uptake (Donald, 1963). Schwerzel and Thomas (1971) concluded that cotton crop took 16 weeks for canopy development to cover 95 per cent of land area whereas weeds took only 8 weeks due to increased light use efficiency and their quick growth rate. The soil moisture removed by weeds was 3 to 5 times more than that of cotton (Schwerzel and Thomas, 1971). The weeds like common cocklebur and johnson grass extracted soil water from greater depths than cotton, while velvet leaf competed for moisture throughout the crop season (Jacobson *et al.*, 1994). However in fine textured soils water stress at the surface due to longer irrigation intervals inhibited the growth of yellow nutsedge than compared to its effect on deep rooted cotton (Jody and William, 1998).

**Critical period of crop-weed competition**

The critical period of crop-weed competition is defined as that shortest time span in the ontogeny of crop when weeding will result in the highest economic returns. The crop yield levels obtained by managing the weeds during this period should provide crop yields sufficiently close to those obtained by the full season freedom from weeds (Gupta, 1998).

Various workers have established the critical period of crop weed competition in cotton. Kerkhovan (1964) reported that the first 50 days of cotton crop was the most critical period for the weed competition. According to Martinez and Nieto (1968), cotton yield was higher if the field was free from weed for the first 60 days. The results of Thomas and Schwerzel (1968) reveal that the critical period of weed competition was 2 - 4 weeks in summer cotton, while a longer period in winter crop. Many workers observed 3 to 5 weeks as the critical period of weed competition in cotton under varying ecosystems (Carson, 1975; Dason *et al.*, 1975; Blaco and Olieveria, 1976; Roger *et al.*, 1976; Mohamed Ali and Bhanumurthy, 1985). Buchanan and Burns (1970) observed that cotton produced maximum yields when kept free of annual weeds for approximately 8 weeks after emergence.
The most critical period up to 70 days from sowing was observed by Sankaran (1977), Drennen and Jennings (1977), Bir and Sindhu (1984), Salome (1984) and Zeman (1985). In rainfed cotton, critical weed competition period lies between first 20 and 60 days of sowing (Sabelke and Bhosle, 1990). Weed competition in the period 28-42 days after planting had the greatest effect in depressing cotton yields (Douti, 1998).

**Effect of weed competition on cotton growth, nutrient uptake and yield components**

Decrease in plant height due to weeds was observed by several workers viz., Balasubramanian and Sankaran, 1976; Rangiah et al., 1976; Virk et al., 1982; Singh, 1983 and Rushing et al., 1984. Snipes et al., 1982 reported that plant height and stem diameter of crop that are major contributors of plant dry matter production, were reduced by weed competition. However, Schwerzel and Thomas (1971) and Sankaran and Rathinam (1974) reported that plant height was not affected even when the crop was left unweeded.

The rate of dry matter production was slow until flowering and after the first boll opened (Halevy, 1976). Dry matter production of cotton was slow during 40 to 80 days following seeding (Bassett et al., 1970). According to Sankaran and Rathinam (1974), Tripathi and Singh (1978) and Singh (1983), the dry matter production of cotton crop per unit area was the lowest under unweeded condition.

Balasubramanian (1975) stated that weeds removed 40.9 kg N ha\(^{-1}\) in the unweeded plot, whereas it was reduced to 14.4 kg ha\(^{-1}\) due to herbicide application. Subramanian (1976) estimated an yield reduction of 11-92 kg ha\(^{-1}\) of cotton for every 1 kg of N removed by weeds. During the first 45 days, the weeds removed 41, 6 and 29 kg NPK ha\(^{-1}\), while cotton removed only 20, 3 and 9 kg NPK ha\(^{-1}\) (Sankaran, 1977). Balasubramanian and Sankaran (1978) concluded that N, P and K uptake of crops was increased by three times if proper weed control measures were taken up. Weeds removed 5-6 times N, 5-12 times P and 2.5 times K compared to cotton uptake under upland situation (Jain et al., 1981). According to Chander et al. (1994), herbicides alone or in combination with one hand weeding reduced the dry weight and nutrient uptake of weeds significantly. Lower uptake of N, P and K was observed in crop and higher uptake by weeds with unweeded condition (Mani, 1975 and Detroja et al., 1992).

Weeds causes two types of yield losses. The most important one is the direct yield loss resulting from competition, followed by the indirect loss from reduced crop quality. Yield
reduction in cotton is mainly due to severe weed competition in the initial stages. Yield reduction in cotton due to weed competition was to the tune of 30 per cent due to inadequate weeding (Virk et al., 1982), 67 per cent over cultivator’s practice (2 HW) (Wagh et al., 1992) and 30 - 80 per cent depending on the weed density, soft and rainfall (Rout and Sathapathy, 1998). Choudhary (1981) observed that weed suppression was increased by higher population of cotton crop.

Season-long competition of yellow nut sedge Cyperus esculentus (L.) reduced seed cotton yield upto 34 per cent (Jody and William, 1998) while competition from Xanthium strumarium (L.) and Datura stramonium (L.) reduced cotton yields by 28 and 15 per cent, respectively (Byrd and Coble, 1991). The cotton kapas yield reduction of 9.83 kg ha⁻¹ day⁻¹ was observed with 100 Trianthema portulacastrum (L.) m⁻² and the yield reduction increased to 14.23 kg ha⁻¹ day⁻¹ for 200 weeds m⁻². This accounted for 42.4% yield reduction with 200 weeds present in the field for 50 days (AICRPWC, 1997).

The quality of cotton produced was not much affected by associated weeds [Klingman (1973), Buendia et al. (1976) and Rushing et al. (1984)]. Sayed et al. (1979) found that weed competition did not affect the ginning per cent of cotton. Singh and Nagwekar (1989) stated that chemical weed control methods also had no effect on ginning per cent. Seed weight and fibre per cent were also not affected by herbicide application (Nobrega et al., 1997).

WEED CONTROL METHODS IN COTTON

Hand weeding twice (20 and 40 DAS) or two weedings + two hoeings is most common method of weed control in cotton (Wagh et al., 1992).

Manual weed control in cotton

Manual weed control is by far the oldest, most practical, cultural method of weed control that utilise manual energy, simple hand tools to control weeds and followed widely. Manual control of weeds is safe to crop, environment and to the user (Gupta, 1998).

Jain et al. (1985) reported that two interculturations along with two hand weedicings at 30 and 60 DAS gave the best weed control and produced higher yield of seed cotton (1.205 kg ha⁻¹). Significantly higher yield attributes and yield were reported by Nehra et al. (1992) for hand weeding twice than chemical weed control. Dry matter production and nutrient uptake of cotton were maximum in conventional method of manual weed control (Singh and Verma, 1988). Total removal of nitrogen and phosphorus by weeds was lowest in 2 weedings + 2 hoeings than pre emergence applied chemical control (Wagh et al., 1992). A seed cotton yield of 2140 kg ha⁻¹ was obtained under two hand weedicings with higher weed control efficiency of 63.6 per cent (Tiwana and Brar, 1990). Yadav et al. (1995) reported that pendimethalin (Pre) + diuron (Post) and hoeing twice with tora + weeding twice with Khurpi gave the highest yield. Results from Cotton Research Station, Nanded revealed those three manual weedicings at 15, 45 and 75 DAS + three intercultures at 30, 60 and 90 DAS registered highest seed cotton yield (Jadhav et al., 1995). However, weed free check registered maximum weed control efficiency and seed cotton yield over all the treatments (Pagar et al., 1995).

Chemical method of weed control

Traditional methods of mechanical/cultural weed control (hand weeding and hoeing) though used widely by the cultivators, are laborious, time consuming, expensive on account of scarcity of labour, particularly during peak period of intercultural operations and partially effective because most of weeds particularly those growing in rows, escape removal (Singh et al., 1992 and Pagar et al., 1995).
Often incessant rains in spells make the manual weeding impossible (Rajeswari and Charyulu, 1996). These drawbacks in manual weed control resulted in inadequate weed control and low yield in cotton. Thus chemical weed control became a competitive and promising way to control weeds at initial stages of crop growth.

**Pre-emergence chemical control**

Pre-emergence application of soil-active herbicides are commonly applied to the surface of the soil and these herbicides should be able to move into upper 3.5 to 4 cm of soil under the influence of irrigation to kill the germinating weeds (Gupta, 1998). Their use would be appropriate not only for minimizing early weed competition, but also for reducing the work load during the peak labour period; they avoid at least one or two intercultivations during the first 3 to 4 weeks and control weeds in the inter-row as well as within the row (Baker and Terry, 1991).

Pendimethalin is a pre-emergence herbicide used to control grasses and broad leaved weeds in many field crops and cotton (Balyan et al., 1983; Panwar and Malik, 1992). Jain et al. (1985) recommended pre-plant incorporation of pendimethalin 1.5 kg ha\(^{-1}\) for effective weed control in cotton. Panwar et al. (1988) found that application of pendimethalin and fluchloralin each at 1 kg ha\(^{-1}\) effectively controlled carpet weed *Trianthema portulacastrum*, (L.) but less effective on barnyard grass (*Echinochloa colona*, (L.) P. Beauv. According to Singh and Malik (1993), pendimethalin alone at 1.5 kg ha\(^{-1}\) provided higher yield. Panwar and Malik (1992) reported that effect of fluchloralin 1.5 kg ha\(^{-1}\) remained lower than pendimethalin 1.5 kg ha\(^{-1}\). According to El-nagar et al. (1996), pendimethalin at 3.0 kg ha\(^{-1}\) provided best weed control upto 75 DAS. Panwar et al. (1997) found that pendimethalin 1.5 kg ha\(^{-1}\) without supplementary hoeing or herbicides increased seed cotton yield. Diethyl ether 1.5 kg ha\(^{-1}\)and Fluchloralin 0.75 kg ha\(^{-1}\) recorded equal and higher yield in cotton (Panwar et al., 1988; Chandrasekeran et al., 1989; Soliappan et al., 1992).

**Sequential application of herbicides**

Pre-emergence herbicides inhibit seed germination and arrest seedling growth of weeds depending on their mode and mechanism of action. Normally a follow up hand weeding is done after pre-emergence herbicide application to achieve satisfactory weed control at least unto the critical period of crop-weed competition. Alternatively, sequential application of post-emergence herbicide after pre-emergence application found to be active on late emerging weeds (Singh and Arya, 1994). Application of diuron 1.125 kg ha\(^{-1}\) as pre-emergence + diuron 0.75 kg ha\(^{-1}\) as post-emergence recorded higher seed cotton yield (Detroja et al., 1992).

**INTEGRATED WEED MANAGEMENT IN COTTON**

Integrated weed management is a systemic approach whereby whole land use planning is done in advance to minimise the very invasion of weeds in aggressive forms and give crop plants a strongly competitive advantage over the weeds (Gupta, 1998).

A pre-emergence herbicide takes care of weeds only for a limited period and do not give long term weed control in a long duration crop like cotton where the problem of late emerging weeds arises and escape killing. So to attain a season-long weed control, integration of chemical, mechanical and cultural methods holds a great promise in crop like cotton.

Panwar et al. (1994 and 1995) found that requirement of one hoeing before or after spraying pendimethalin may assist through improved soil moisture conservation and the removal of weed population in cotton. Brar et al. (1995) stated that pre-emergence application of pendimethalin 1.5 kg ha\(^{-1}\) followed
by one hoeing at 30 DAS is effective for the control of annual broad leaved and grassy weeds like *Trianthema portulacastrum* (L.) and *Eleusine indica* (L.) Gaertn. in cotton. According to Pagar *et al.* (1995), pendimethalin 1.05 kg ha\(^{-1}\) proved effective than fluchloralin 1.125 kg ha\(^{-1}\) as pre-emergence in combination with one hand weeding and hoeing in increasing the seed cotton yield (8.88 q ha\(^{-1}\) and 7.95 q ha\(^{-1}\) respectively). Giri *et al.* (1998) stated that integration of chemical (Diuron 0.5 kg ha\(^{-1}\) or Fluchloralin 0.9 kg ha\(^{-1}\) (PE) or Pendimethalin 0.75 kg ha\(^{-1}\) (PE)) supplemented with cultural (weeding and hoeing at 6 weeks after sowing) practice was as effective as the recommended cultural weed control method in achieving weed control efficiency and enhancing seed cotton yield. However, use of chemical alone (pendimethalin 1 kg ha\(^{-1}\)) without supplemental hand weeding resulted in lower yield compared to farmer’s practice of two or three manual weeding (Detroja *et al.*, 1992). Pre sowing application of fluchloralin 1 kg ha\(^{-1}\) in combination with one handweeding at 60 days or pre-emergence application of diuron 1 kg ha\(^{-1}\) in combination with one hoeing at 60 days were equally effective and resulted in similar seed cotton yield (Wagh *et al.*, 1992; Rajeswari and Charyulu, 1996).

REFERENCES