Weed flora, yield losses and weed control in cotton crop

Unkrautflora, Ertragsverluste und Unkrautkontrolle in Baumwolle

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Abstract

Cotton (*Gossypium* spp.) is the most important fiber crop of world and provides fiber, oil, and animals meals. Weeds interfere with the growth activities of cotton plants and compete with it for resources. All kinds of weeds (grasses, sedges, and broadleaves) have been noted to infest cotton crop. Weeds can cause more than 30% decrease in cotton productivity. Several methods are available for weed control in cotton. Cultural control carries significance for weed control up to a certain extent. However, mechanical control and chemical control are the backbone of weed management plans in cotton crop. Use of allelopathy has also been found effective for suppressing weeds in cotton. Allelopathy used in several forms (such as intercropping, mulches, and crop rotation) contributes to weed control in cotton crop. All of these weed management practices may be integrated to achieve economical and sustainable weed control in cotton with an ultimate result of improved weed control, productivity, quality of produce in cotton crop.

Keywords: Cotton, weed-crop competition, weed management, yield losses

Zusammenfassung

Baumwolle (*Gossypium* spp.) ist die bedeutsamste Faserpflanze der Welt und dient als Faser-, Öl- und Tiernahrungsquelle. Unkräuter beeinträchtigen das Wachstum der Baumwollpflanzen indem sie mit den Pflanzen um essentielle Ressourcen konkurrieren. Verschiedene Unkrautarten (Gräser, Seggen und dikotyle Arten) sind in Baumwolle bekannt und können zu Ertragsverlusten von mehr als 30 % führen. Für die Unkrautkontrolle in Baumwolle stehen verschiedene Verfahren zur Verfügung. Die Anwendung von ackerbaulichen Maßnahmen kann zu einem gewissen Teil zur Unkrautbekämpfung beitragen. Mechanische und chemische Verfahren werden aber als die wichtigsten Maßnahmen zur Unkrautkontrolle in Baumwolle angesehen. Auch der Einsatz von allelopathischen Einflüssen kann als wirkungsvolle Maßnahme eingestuft werden. Allelopathie kann in verschiedenen Formen (Zwischenfrüchte, Mulch and Fruchtfolge) genutzt werden und so zur Unkrautkontrolle in Baumwolle beitragen. Um eine ökonomische und nachhaltige Unkrautbekämpfung in Baumwolle sicherzustellen, sollten alle genannten Verfahren gemeinsam eingesetzt werden. Nur so kann das Ziel einer verbesserten Unkrautkontrolle, einer erhöhten Produktivität und einer verbesserter Qualität der Baumwolle erreicht werden.

Stichwörter: Baumwolle, Ertragsverluste, Unkraut-Kultur-Interaktion, Unkrautmanagement

Introduction

Cotton is not only among the most important cash crop of world but also a source of several of our daily use-items. Cotton provides raw material for fiber, clothes, vegetable oil, and animal meals. Moreover, the crop remains of cotton plants can be used as manure. Cotton was grown in Indus valley of Pakistan more than 3000 years BC (IQBAL et al., 2001; MOULHERAT et al., 2002).

Cotton has four species which are under cultivation worldwide. These are *Gossypium arboretum* L., *Gossypium barbadense* L., *Gossypium herbaceum L.* and *Gossypium hirsutum* L. Nevertheless, G. hirsutum is the most grown species of cotton which more than three-fourth area under this crop. Growing cotton requires a warm environment with a low relative humidity (USMAN et al., 2013). China, India, USA, Pakistan and Brazil are the most important cotton producing countries of world. Australia is the country which obtains highest per hectare yield of cotton (http://www.indexmundi.com/agriculture/?commodity=cotton&graph=yield).

Cotton can be planted by using either the conventional tillage or conservation tillage (BLAISE, 2006; USMAN et al., 2013). Moreover, cultivation of organic cotton is also getting popularity these days. Usually, wide distance is maintained between the crop rows by wide placement of seeds, while plants are sown close enough to maintain rows with low plant-plant distance. Sowing of cotton crop on beds or ridges can result in considerable reduction in water inputs for optimum crop productivity (THIND et al., 2010). Variety of cotton planters are available which can plant cotton seed on all kind of soils i.e. either flat, beds or ridges. Produce can be picked from mature cotton plants (just at or before the start of winter season) with the help of mechanical harvester or manually.

Cotton plants are highly sensitive to abiotic and biotic stresses. The abiotic stresses on cotton may include a moistures stress (usually a drought stress), heat stress and salinity stress (LAW et al., 2001; LUO et al., 2008; MASSACCI et al., 2008). Biotic stresses are more damaging for cotton crop that the abiotic stresses. Cotton is among the crops which are attacked by hundreds of pests in the form of viruses, disease pathogens, insect pests and weeds which together can cause a yield loss of >80% in this crop (OERKE, 2006). A number of weed species infest the cotton fields (DOGAN et al., 2014). Weeds such as *Cynodon dactylon* (L.) Pers., *Trianthema portulacastrum* L., *Convolvolus arvensis* L., *Cyperus rotundus* L., *Conyza canadensis* L. and *Sorghum halepense* (L.) Pers. can be quoted as the most important examples in this regard (KALIVAS et al., 2012; DOGAN et al., 2014). The weeds can severely decrease cotton productivity and can negatively affect the lint quality. In this article, we have reviewed the important weeds of cotton crop, the yield losses caused by these weeds and the salient weed control methods in cotton.

In addition to yield losses, weeds can also pose other damages to cotton crop. This can include a provision of habitat to other pests such as viruses, insect pests and disease pathogens. *Ambrosia artemisiifolia* L. co-occurring in cotton was found to support the survival of cotton insect pest *Bimisia tabaci* (ZHANG et al., 2014). Also, many of cotton weeds create a difficulty in the harvest of the crop (SMITH et al., 2000).

A critical issue for weed management in cotton is the evolution of herbicide resistant weeds. Abundant use of specific herbicides caused a selection of tolerant species which ultimately resulted in build-up of a pool of resistant weeds. The situation is particularly alarming for fields where glyphosate has been used in glyphosate-resistant cotton. Many weeds have become resistant while several are increasing their tolerance to applied doses of glyphosate (WEBSTER and SOSNOSKIE, 2010). For example, *Commelina benghalensis* L. and *A. palmeri* (WEBSTER and SOSNOSKIE, 2010). Evolution of multiple resistance (against glyphosate and pyrithiobac, an ALS-inhibiting herbicide) is also on record for problematic weeds like *A. palmeri* (SOSNOSKIE et al., 2011). The best way to deal the danger of herbicide resistance evolution in weeds is the use of integrated weed management and practice most appropriate agronomic management techniques (NORSWORTHY et al., 2012).

Weed flora, and yield losses in cotton

A very rich weed flora infests cotton fields. Weed types such as sedges, grasses and broadleaves can be noted to compete with cotton crop. The most important weeds in cotton crop include *Amaranthus palmeri* S. Watson, *Amaranthus retroflexus* L., *Ambrosia artemisiifolia* L., *Chenopodium album* L., *Convolvulus arvensis* L., *Cucumis melo* L., *Cynodon dactylon* (L.) Pers., *Conyza canadensis* (L.) Cronquist, *Cyperus rotundus* L., *Digitaria sanguinalis* (L.) Scop., *Eleusine indica* (L.) Gaertn., *Portulaca oleracea* L., *Solanum nigrum* L., *Sorghum halepense* (L.) Pers., and *Xanthium strumarium* L. (CULPEPPER and YORK, 1998; SMITH et al., 2000; WOOD et al., 2002; TINGLE and STEELE, 2003; KALIVAS et al., 2012; ÖZASLAN and BÜKÜN, 2013; USMAN et al., 2013; DOGAN et al., 2014; BERGER et al., 2015; XIAO-YAN et al., 2015).

Negative impact of weeds on yield and quality of cotton are also evident. Weeds can suck more water than cotton plants and compete for light and nutrients with cotton plants, ultimately the yields are decreased significantly (BERGER et al., 2015; NALINI et al., 2015). Four plants of *E. indica* in one meter row of cotton crop were found to decrease number of bolls per plant by 25% and the cotton yield by >20% (XIAO-YAN et al., 2015). In another study, *C. melo* reduced the cotton yield by

34% if ten plants of this weed were present in a ten meter long row of cotton (TINGLE and STEELE, 2003). Overall, weeds have the potential to reduce the global cotton production by more than 35% (OERKE, 2006).

Preventive weed control in cotton

Like all other crops, the major focus should be on preventive measure for controlling weeds in cotton. Clean cultivation, use of clean (weed-seed free) seed, fertilizer and water can be mentioned as salient preventive weed control techniques for cotton crop (RIAR et al., 2013). Clean cultivation focus on keeping the field, its boundaries, water channels, farm roads and farm area free from weeds and their germ plasm (FRISVOLD et al., 2009). The objective of this is to keep a check on spread of weeds in the cotton fields. In many farms (particularly in developing countries), the farmers may use a cotton seed which was produced at their own farm. Such seeds can contain weed-seeds which will help in spread of weeds in the coming season. Use of weed-seed free cotton seed is advocated to keep the cotton fields free from weeds in upcoming crop season (FRISVOLD et al., 2009). Fertilizer (farm manures) and water may contain some weed-seed which can aggravate the issue of weeds in cotton. Principally, farm manure and water applied to cotton crop should not contain any kind of foreign objects or weed seeds. In addition, farm machinery may be cleaned after using in a field containing weeds. Another important part of preventive measure includes cutting of mature weed plants before the spread their seeds (RIAR et al., 2013).

Cultural weed control in cotton

Cultural practices are important after preventive measure as environment friendly techniques. All across the globe, several cultural weed control options are available for cotton crop. Such practices are cheap or even costless, and are easily adjustable in the weed management plan for cotton. The most important of these may include crop rotation, stale seedbed, soil solarization, suitable sowing time, use of appropriate variety, plant spacing and sowing method for weed control in cotton.

Crop rotation in general improves the crop productivity through its advantages such as improved weed control, improved soil productivity and others. Crop rotation if performed will damage the established (cotton associated) weeds. For example, if field is put under rice rather than cotton for a season, this tactic may help in control of many weeds such as sedges. Stale seedbed is another important cultural practice for suppressing weeds in cotton. Using this technique, the germinated weeds in ploughed and fallow fields are controlled by employing tillage or a non-selective herbicide (DOGAN et al., 2009). Ultimately, weed-free fields are available for sowing cotton and subsequent healthy crop and high yields. Soil solarization is a cultural technique like stale seedbed. In this method, the ploughed and fallow fields are covered with plastic sheets. These sheets raise the soil temperature by entrapping the sunlight. The temperature of soil environment is raised significantly which causes death of weeds and also damages the weeds seeds. Cotton is grown in warm areas, hence, the soil solarization (as a technique that uses sunlight to kill weeds) is an appropriate technique for cotton crop.

There are several agronomic management techniques which can help to lower the levels of weed infestation in cotton. For example, sowing time of cotton can be adjusted in accordance with the appearance time of first flush of weeds in cotton fields. Moreover, sowing a competitive cotton variety and planting seeds close can improve the competitiveness of cotton crop against weeds.

Generally, a very fine seedbed is prepared for cotton crop. Unless the farm is following a conservation agriculture system, the field is ploughed, cultivated and ploughed more than once before sowing the cotton seeds (KEISLING et al., 1995). In many farms, well-prepared seedbed is given the shape of beds or ridges for sowing cotton seeds. All of this process helps to kill all the germinated weeds in the field. Ultimately, a weed-free cotton field is provided for several days after crop sowing. An important way is to combine flat sowing of cotton with ridge sowing. This means half of the crop season, the cotton crop is on flat field, while for rest of season, it is on ridges. In this scheme, the crop is sown on flat land that will be followed by natural emergence of weeds. The emerging weeds may be treated with a mechanical hoeing, the same field is then made into ridges by adding soil on both sides of cotton plant trunks with help of ridger. This will help to burry most of the weeds infesting field. This method has been reported very effective in suppressing the weeds in cotton field. Modern robotic machines can also play a significant role in killing the weeds in cotton fields. However, more research work is needed for successful launch of such weed control programs.

Mechanical weed control in cotton

Mechanical control has a significant role in weed management plans in cotton crop (OWEN et al., 2015). A wide variety of tools are available for accomplishing mechanical weed control in cotton. These include the conventional tractor drawn weeders as well as manually operated robot weeders. Recently, automatic robot weeders have also been developed for weed control in cotton. In many parts of world, farmers use to practice mechanical weed control in cotton with tractor drawn weeders. Usually, they repeat this practice more than once in a season depending on the intensity of weed infestation in the field.

Hand-weeding is still practiced in several parts of world. The established weeds can particularly be eradicated using hand-pulling or hand-hoeing. A few plants of a notorious weeds which were not controlled by other weed control methods (such as herbicide resistant weeds) may be destroyed by hand-weeding (OWEN et al., 2015). Hand-weeding may have an important role where cotton is grown for subsistence farming (MAVUNGANIDZE et al., 2014).

Allelopathic weed control in cotton

Evidence from recent literature indicate that allelopathy can be used for managing weeds in cotton (KHALIQ et al., 2007; FAROOQ et al., 2011; JABRAN et al., 2015). Allelopathic crops such as sesame, soybean and sorghum intercropped with cotton helped to control weeds, improve the dry matter production by cotton plants and increase the lint yield and economic benefits (IQBAL et al., 2007). Other than intercropping, the allelopathic cover crops grown in cotton rows can help to suppress the weeds (VASILAKOGLOU et al., 2006). The cover crops are reported to have suppressive effect against weeds and neutral effect on growth of cotton plants (VASILAKOGLOU et al., 2006). Similarly, another way is to use allelopathic plant residues between the cotton rows for controlling weeds (CAAMAL-MALDONADO et al., 2001).

Chemical weed control in cotton

Herbicides have a great role in managing weeds in cotton. Herbicides make the weed control in cotton easy, efficient and economical. Pre-emergence herbicides are the first option for chemical weed control in cotton. Some early post-emergence herbicides are also available for application in cotton. In addition, lay-by application of non-selective herbicides for weed control in cotton has also been reported (OWEN et al., 2015). Introduction of glyphosate, dicamba and glufosinate resistant cotton helped to revolutionize the weed control in cotton.

Knowledge about the current weeds infesting a cotton field is important for deciding the most appropriate herbicide. Information regarding the kind of weeds, their growth stage and density will help to select the proper chemical treatment. All of this information should be obtain through mapping weeds individually in each field at a particular farm.

Pre-emergence herbicides are usually applied before or immediately after the seedbed preparation but generally prior to crop sowing. Under certain cases, pre-emergence herbicide application immediately after cotton sowing has also been noted. Moisture content is important for herbicide activity in the soil. Pendimethalin and trifluralin are the most common herbicides that are applied for a pre-emergence weed control in cotton (KEELING et al., 1996). The others in this list may include fluometuron and metolachlor (CULPEPPER and YORK, 1998; KRUTZ et al., 2009). Post-emergence herbicides are also available for weed control in cotton. For example, post-emergence application of trifloxysulfuron-sodium was effective in controlling several weeds in cotton (BRECKE and STEPHENSON, 2006). *Melochia corchorifolia* L., *Desmodium tortuosum* (Sw.) DC., *Senna obtusifolia* L. and *Ipomea lacunosa* L. were found highly susceptible to this herbicide in the cotton fields (BRECKE and STEPHENSON, 2006). Other post-emergence herbicides effective in suppressing weeds in cotton may include haloxyfop-R-methyl, haloxyfop-R-methyl + lactofen, and fluazifop-P-butyl (GRICHAR et al., 2003; USMAN et al., 2013). An option of using early post-emergence or post-emergence as lay-by application of herbicides is also available for controlling weeds in cotton (BARNETT et al., 2013).

Herbicide resistant cotton allows a free application of non-selective herbicides for control of all kind of weeds. For example, B2XF cotton is a glyphosate-, glufosinate- and dicamba-resistant cotton variety which has been releases for cultivation. Early post-emergence application of dicamba was highly effective in controlling *A. palmeri* which is among the problematic cotton weeds (CAHOON et al., 2015). Similarly, cotton variety 'GlyTol® LibertyLink® cotton' allows a combined application of glyphosate and glufosinate. This provides a highly effective weed control in cotton (REED et al., 2014).

Conclusions

Several weeds infest the cotton fields, compete with cotton plants for moisture, light and nutrients, and decrease the cotton productivity and fiber quality. Evolution of herbicide resistance in weeds is one of the major issues in successful accomplishment of weed control in cotton. Multiple weed control options including allelopathy, cultural practices, mechanical control and herbicide application are available for weed control in cotton. Use of more than one of these methods in integration with each other may provide long-term weed control.

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