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Cotton Production and Management :A Term Paper

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Abstract
This review paper was aimed to review cotton production areas and important management practices. In this review work, major cotton production potential areas in the world are clarified. The review found that cotton was first cultivated in South Asia and South America. However, the review paper revealed that the two species used in South Asia (*Gossypium herbaceum* and *G. arboreum. G.herbaceum) were* originated in Africa. It is found that Ethiopia is believed to be one of the origins of cotton, and cotton cultivation is deep-rooted in the history of the country's agriculture. Cotton is one of the major cash crops in Ethiopia and is extensively grown in the lowlands under large-scale irrigation schemes Trade in cotton fabrics between Asia and Europe was established during the time of Alexander the Great.

1. INTRODUCTION

Cotton was first cultivated in South Asia and South America. Cotton fragments found in the Indus Valley date to 3000 BC. The two species used in South Asia were *Gossypium herbaceum* and *G. arboreum. G.herbaceum* originated in Africa. Trade in cotton fabrics between Asia and Europe was established during the time of Alexander the Great. In the 1600s, Europeans discovered that cotton plants were also being grown in the Americas. These New World cotton cultivars were superior for mechanized cloth production because of their longer fibers.New World cotton varieties were introduced in to Africa in the 1800s, eventually displacing local varieties (Isaacman,1996).

Cotton can be seen as one important thread of the globalization process in Africa. Through a set of linked case studies, we can comprehend the nested dynamics of the crop in the soil, in local African communities, in national political economies, and in international circuits of power and commerce. Thus, the overarching conceptual framework of the volume is that of the commodity chain (Isaacman,1996).

The word 'cotton' refers to four species in the genus *Gossypium* (Malvaceae) ,*G. hirsutum* L., *G. barbadense* L., *G. arboreum* L. and *G. herbaceum* L.that were domesticated independently as source of textile fibre (Brubaker et al. 2015a).The textile industry was one of the first manufacturing activities to become organized globally, with mechanized production in Europe using cotton from the various colonies(Isaacman and Roberts 1995).

Ethiopia is believed to be one of the origins of cotton, and cotton cultivation is deep-rooted in the history of the country's agriculture. Cotton is one of the major cash crops in Ethiopia and is extensively grown in the lowlands under large-scale irrigation schemes. It is also grown on small-scale farms under rain-fed agriculture (Ethiopian Investment Agency,2012)

Objectives

To review major cotton producing countries of the world
To review the important cotton production packages

2. COTTON PRODUCTION AND MANAGEMENT

2.1. Cotton Production

2.1.1. World Cotton Production

World cotton production for 2013 was 117.22 million bales—down 5.87 million bales or 4.8% from 2012 (Figure 2). Production has trended down since 2011. During this same time, Use (demand) has begun to slowly recover from the low in 2011 but production still outpaces demand annually by roughly 6.5 million bales. Production has been higher than Use for 4 consecutive years (2010-13) compared to Use outpacing production for each of the prior 5 years (**Souwww.ugacotton.com)**

According to James *et al* (2014) estimated 2013/14 cotton production by leading countries of the world ;China,India ,Pakistan and Brazil is about 32 million bales, 29 million bales, 9.5million bales, 7.4 million bales.China is expected to produce 9% lower production from that of 2012/13 prodction season. The other two countries and Brazil are expected to increase their production by 2% and 23% respectively.Based on James et al (2014) the expected area under cotton production for China,India, Pakistan and Brazil in2013/14 production season is about 5.1 million,11.7 million,3.0 million and 1.2 million hectares respectively.

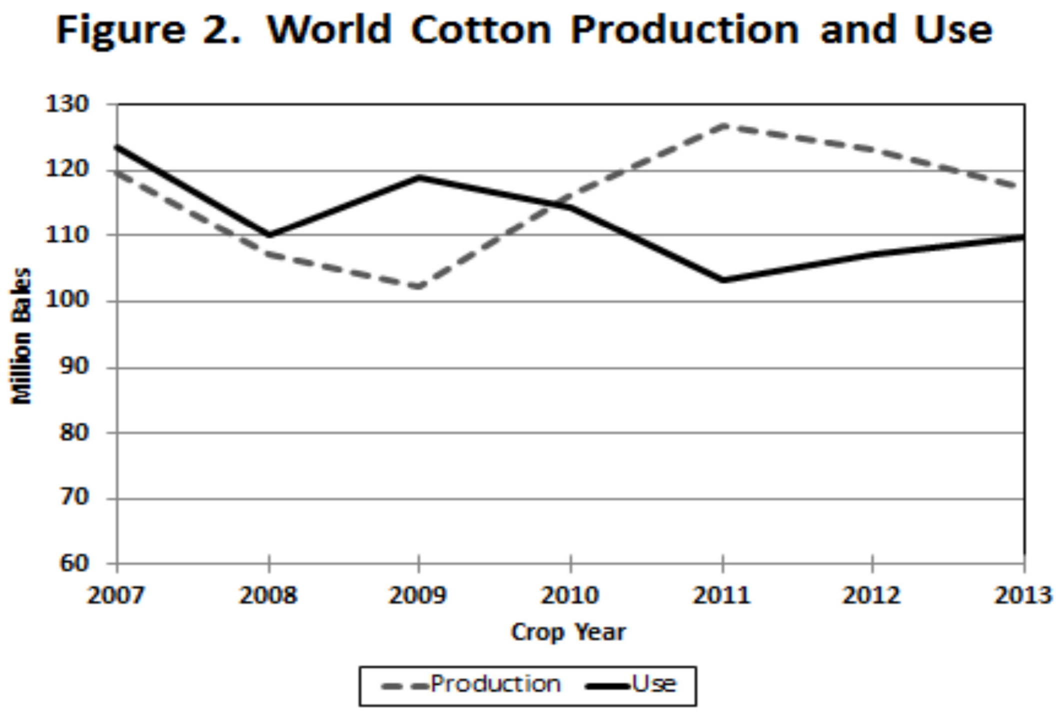

Figure 1. Global Cotton Production and Use
Source: www.ugacotton.com

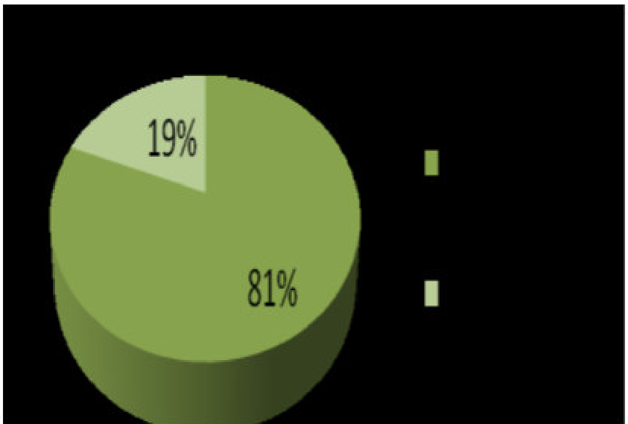

Figure 2. Global cotton production: 19% developed countries and 81% developing countries

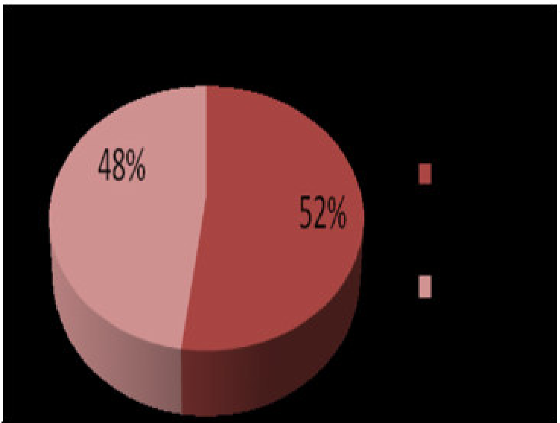

Figure 3. Global cotton Export: 48% developed countries and 52% developing countries countries

Table 1. Country Ranks on Productivity of Cotton

Rank	Country	Yield (kg/ha)
3	Turkey	1,620
4th	Brazil	1,524
5th	China	1,484
6	Mexico	1,476
7	Venzuela	1,234
8	Peru	1,125
9	Syrian Arab Riublic	1,089
10	Tunzia	1,089
17th	Pakistan	742
77th	Congo	109
56th	Ethiopia	327

Source: www.indexmudi.com,2014.

2.1.2. Africa Cotton Production

The major cotton producers in Africa are Mali, Côte d'Ivoire,Benin, Burkina Faso,Zimbabwe and 200.1, 160.4,147.6, 134.4 and 122.7 thousands of tonnes respectively (*William and Leslie,2003)*

2.1.3. Cotton Production in Ethiopia

Ethiopia is believed to be one of the origins of cotton, and cotton cultivation is deep-rooted in the history of the country's agriculture. Cotton is one of the major cash crops in Ethiopia and is extensively grown in the lowlands under large-scale irrigation schemes. It is also grown on small-scale farms under rain-fed agriculture (Ethiopian Investment Agency, 2012)

Ethiopia annually produces approximately 120,000 tons of cotton (Central statistics Agency). Much of the cotton production in Ethiopia is from small-scale farmers, who cultivate about 39,600 hectares annually. The total area under cotton plantation by the private owned enterprises is 54,000 hectares Ethiopian Investment Agency, 2012)

Table 2. Water and Irrigable Land Resources of the River basins in Ethiopia

No.	River basin	Catchment area (Km2)	Annual runoff (BM3)	Gross potential irrigable area ('000ha)	Developed (irrigated) area ('000 ha)
1	Abbay	199812	52.6	815.58	13.98
2	Awash	112700	4.6	134.12	122.36
3	Baro-Akobo	74100	23.6	1019.52	1.32
4	Genale-Dawa	171050	5.8	1074.72	2.29
5	Mereb	5700	0.26	7.38	0.24
6	Omo-Gibe	78200	17.9	67.93	10.75
7	Rift valley	52740	5.6	139.30	21.90

Source: Ministry of Water and Energy, 2010

2.1.3.1. Potential Areas

Cotton has grown in many of regions in the country. In each region there are wide potential areas according to the table two below in Tigray 269130ha, in Amhara 678,710 ha, in SNNPR 600,900 ha, in Oromia 407420 ha, Gambella 316,450, Benshangul 303,170ha, Afar 200,000 ha and Somali 225,000ha. Most of the areas are low land and at river basins. The minimum lease price is 111 birr/ha/ year Ethiopian Investment Agency,2012)

Table 3. Cotton Potential Areas of Ethiopia

.NO.	Product	Potential area	farm	Hectare	Lease price (Br/ha/yr)
1	Cotton				Minimum 111 the maximum 3077
			Tigray	269130	
			Amhara	678710	
			SNNP	600930	
			Oromiya	407420	
			Gambella	316450	
			Benshangul	303170	
			Afar	200000	
			Somali	225000	

2.2. Cotton Management

2.2.1. Irrigation

Although cotton is considered to be a relatively drought-tolerant crop, it is an excellent candidate for irrigation. Irrigation is particularly important in areas that frequently have drought in July through August 20 and on sandy soils. Irrigation may increase yields from a range of 0 to more than 800 lb/A, with increases of 200 to 400 lb/A being common. Irrigation is often used as a supplement to rainfall, as total reliance on irrigation in the absence of periodic rainfall would be difficult for some producers. The most critical period is during the bloom and boll maturation periods. At peak bloom, the plant needs about 0.3 inches of water per day. However, recent UGA research as indicated that timely irrigation with moderate rates during squaring (period when potential fruting sites are developing) may also have a strong influence on yields(Georgia Cotton Commission,2014)

Table 4. Cotton Irrigation Schedule Suggested for High Yields

crop Stage	Inches/Week	Inches/Day
Week beginning at 1st bloom	1	0.15
2nd week after 1st bloom	1.5	0.22
3rd week after 1st bloom	2	0.30
4th week after 1st bloom	2	0.30
5th week after 1st bloom	1.5	0.22
6th week after 1st bloom	1.5	0.22
7th week and beyond	1	0.15

Source: Georgia Cotton Commission, 2014

N.B Examine the crop during the 7th week and 8th week to determine if irrigation should be continued.

Additional irrigation may be needed on deep sands, during hot and dry weather, and in windy conditions. It is generally recommended that irrigation be discontinued when a noticeable number of bolls have opened, especially when the majority of harvestable bolls are located on 63 lower plant nodes. However, if the majority of the targeted harvestable bolls remain relatively immature when only a few lower bolls begin to open, irrigation may still be needed for a short time. Irrigation termination is a difficult decision. A final watering is often made when the crop begins to open. Commonly, NO additional irrigation is applied once the time the crop is 10 percent open to minimize problems with boll rot, hard lock, and light spot. Common sense factors include prevailing weather patterns and predictions, available soil moisture, and time of year (Georgia Cotton Commission,2014).

2.2.2 Altitude

Cotton is basically a crop of warmer climates. In Ethiopia, a good cotton yield is obtainable from areas varying in altitude from sea level to about 1000m. A large area of the Country particularly the country's potential cotton growing areas such as Omo-Ghibe. Wabi Shebele, Awash, Baro-Akobo, Blue Nile, and Tekezze river basins lie within this altitude range Ethiopian Investment Agency,2012).

2.2.3 Temperature

The optimum temperature for cottonseed germination ranges between 19 ^{o}c and 30 ^{o}c for early vegetative growth bud formation and flowering, daytime temperature should be higher than 20^{o}c. Temperature between 27 ^{o}c and 32 ^{o}c are optimum for boll development and maturity. The potential cotton growing areas mentioned above satisfy these temperature requirements for cotton cultivation Ethiopian Investment Agency,2012)

2.2.4. Field Selection

Cotton can be grown in many areas of the state on a wide range of soils. It is best adapted to soils that are moderately deep to deep with good drainage and high moisture-supplying capacity in the drier summer months. Cotton requires a large amount of moisture during flowering and fruiting stages (July and August) for high yields of lint. Well-drained soils will also tend to warm up early in the spring. Selecting longer fields will allow for more efficient use of equipment (Paulus P, 2015).Cotton performs best when the soil is in a pH range from 6.3 to 7.5. Soils with a pH of 6.0 or lower must be limed. Soils with a pH above 8.2 indicate excess sodium and must be reclaimed. Excess salts in your soil or water can significantly reduce yield. . In high salinity areas it is necessary to design the drip system so it can provide adequate leaching. Consult your local extension service for more information on problematic soils in your area. When dealing with problematic soils it is necessary to allow sufficient time for the reclamation process to take effect before planting. Your local Netafim Dealer can give you guidance as to the proper field preparation prior to installation which will make installation go smoothly. (WWW.NETAFIMUSA.COM)

2.2.5. Variety Selection

Choosing which variety to plant is one of the most critical steps in producing a cotton crop and achieving optimal yields and fiber quality. Currently, producers not only choose a variety based on genetic performance or yield potential, but also according to pest management traits or technology packages(Georgia Cotton Commission,2014).

2.2.6. Planting Dates and spacing

- Long term research has shown little yield difference in planting dates between April l and May 20. The "best" planting window varies yearly. Early planting while moisture persists increases the likelihood of successful planting in non-irrigated fields. However, early planting comes with risks, including possible seedling vigor and disease problems associated with cool and/or wet periods, premature cutout related to the coincidence of early fruiting and drought, and late season boll rot due to expected rains in late August or early September. Boll rot is frequent in areas in which boll opening coincides with rainfall, high humidity, and overcast conditions. Seed sprouting from the exposed seedcotton can also be a problem during the fall of some years if similar conditions prevail. In addition to these problems, significant yield loss and quality degradation can occur when lint is exposed to rainfall and wind.For maximum efficiency in weed and disease control, harvesting, etc., establish a population of 30,000 to 60,000 plants per acre. Excessive plant populations will cause higher fruiting on the plants, shorter limbs, smaller bolls and fewer bolls per plant. A stand of three to five plants per foot of row will require four to six seeds per foot of row under normal conditions.Row spacing 25ccccm,38cm or 76cm to get equal lint yield;but 76cm better for lint quality(Steve *et al*;2003).

2.2.7. Soil and Fertilizer

Typical cotton soils are heavy, dark, often cracking soils. Cotton crop also performs well on a variety of lighter sols such as loams. Since cotton is a fairly deep-rooted crop, deep soils of 180cm or more are preferred. The Country's potential cotton growing areas have sols of these types. The cotton plant is very sensitive to soil fertility and production level. It is important to supply all the nutrients that may be needed in each field. Many problems can be related either directly or indirectly to acid soils and low levels of plant nutrients. Fertilization and liming programs should be based on the fertility of the soil. A good soil test is the first step in a sound fertility program. Samples should be taken during fall or early winter and sent to The University of Tennessee Soil Testing Laboratory for analysis and recommendations(Paulus P,2015).

Lime

Soil test summaries from The University of Tennessee Soil Testing Laboratory indicate that many of the samples tested are too acid for best yields without adequate application of lime.Yields will be highest and fertilizers used most efficiently when the pH is 6.0 to 6.5. Calcium supplied by ground limestone aids in setting fruit and proper maturing of bolls. Soil acidity will also influence the availability of some plant nutrients, herbicide activity, seedling development and seedling diseases.Applying high rates of acid-forming fertilizers will gradually lower the soil pH. A 100-pound per acre application of nitrogen in the form of anhydrous ammonia, ammonium nitrate or urea would require approximately 400 pounds of limestone to neutralize the acidity resulting from the nitrogen application.

Nitrogen

The amount of nitrogen needed depends on the soil and its previous cropping history. Application of N 100 lb N/acre is recommended (Stewart,2000).The various nitrogen sources are similar in supplying nitrogen for plant growth. Nitrogen can be applied at or just prior to planting or may be split with side dressing applications no later than early square stage. Anhydrous ammonia should only be used at planting time and placed 4 to 6 inches to the side and 6 inches below the level of the seed. Very low concentrations of ammonia can greatly reduce seed germination. Nitrogen deficiency symptoms first appear on the lower leaves. The leaves of nitrogen-deficient plants become light green to pale yellow. As they age, shades of red develop and then they turn to brown. Leaves then dry out and shed from the plant. The entire plant will be stunted and unthrifty in appearance and fruit set will be reduced.Under nitrogen-deficient conditions, nitrogen can be applied to the soil as a side dressing until about the third week of blooming. Applications of nitrogen to the soil may increase the risk of late-season growth(Paulus P, 2015).

Phosphorous (P_20_5)

is important in early root development, photosynthesis, cell division, energy transfer,early boll development, and hastening of maturity.The amount of phosphorous in a cotton plant is low compared to levels of nitrogen and potassium. Phosphorus fertilization is important to cotton production because it is essential for root development and early growth. Some cotton soils tend to be low in available phosphorus. Phosphorous is an immobile nutrient, so it must be available in the rooting zone for root contact and uptake into the plant. Low phosphorous levels in the soil result in stunted plants. The leaves will be smaller than normal and dark green. Fruiting and maturity may be delayed, making the plant more vulnerable to insects and diseases. Low levels of phosphorous may reduce lint yield, fiber strength and micronaire.The availability of phosphate to the cotton plant is dependent on a good liming program, as pH levels below 6.0 or above 7.0 results in reduced availability(Paulus P, 2015). Recommended to apply 40 lb P2O5/A (Stewart,2000).

Potassium (K_2O)

It is an extremely important nutrient inn cotton production.It affects fiber properties such as length and strength.is important in reducing the incidence and severity of wilt diseases increases water use efficiency the need for K increases dramatically during early boll set About 70 percent of uptake occurs after first bloom, and uptake peaks at about 2 to 3 lb/A (Stewart, 2000)

Many soils on which cotton is grown are low in available potassium. It is not uncommon to see potash-deficient plants. Low levels of potassium cause stunted plants and leaves that fail to develop a normal green color. Mature leaves are often mottled after turning light yellowish-green, then reddish-brown between the veins of the leaf, before the discoloration spreads to the leaf margins. The tips and edges of the leaves curl downward. The leaves become reddish-brown, and are scorched and blackened by the time they are prematurely shed. Bolls are small, immature and may fail to open or only partially open. Lint yield and fiber properties are reduced. The availability of potassium is influenced by the soil pH. Soil tests are necessary to determine both the lime and potassium needed for productive yields. Over the last 10 years there has been an increase in potassium deficiency symptoms in cotton grown in West Tennessee. Problem fields may have adequate levels of potassium in the top 6 inches, but a low level in the subsoil. In some cases the pH level was also low, helping to create the deficiency (Paulus P, 2015).

Boron (B)

Based on (Paulus P,2015) boron deficiency on cotton is more likely to occur on limed soil, particularly after heavy lime applications. Apply boron at the rate of 0.5 pound per acre when soil pH is above 6.0 or where lime is used. Boron can be applied in mixed fertilizer or preemergence herbicides. To obtain .5 pound per acre of boron, apply 2.44 pounds "Solubor" per acre. For foliar application, apply 0.1 pound boron beginning at early bloom making three to five applications at weekly intervals.Some boron deficiency symptoms may be

- Abnormal shedding of squares and young bolls.
- Ruptures at the base of squares or blooms or on the stem (peduncle) that supports the squares.
- A darkened area at the base of bolls, extending inside the boll. (can be detected by cutting across the base of the boll.)
- Mature bolls that are small, deformed and do not fluff normally.
- Death of the terminal bud and shortened internodes near the top of the plant.
- Dark green rings on leaf petioles ("coon -tail" petioles). When petioles are sliced, a discoloration of the pith can be seen in conjunction with the rings.
- Dark green, often thicker leaves. Leaves remain until frost and may also be difficult to chemically defoliate.
- Poor response to nitrogen and potassium.

2.2.8. Insect Pests

Thrips: feed on leaves and terminals of seedling plants, thereby stunting growth and delaying maturity. Damaged leaves appear crinkled on top, and lower surfaces will often have a silvery sheen. Leaf margins become cupped and terminal buds may be destroyed. Tobacco thrips, Frankliniella fusca, is the predominant species encountered in cotton in South Carolina.

Aphids:typically infest plant terminals and uppermost leaves initially. These soft-bodied insects have piercing sucking mouthparts, that are used to suck plant juices from leaves and stems. Heavy infestations on the undersides of leaves produce wilting and cause the leaf margins to curl toward the ground(Jeremy,2014).

Whiteflies:can also damage cotton bysucking plant fluids, but this happens very rarely in South Carolina. These insects are generally controlled by naturally occurring beneficial arthropods before their damage can reduce yields. Both aphids and whiteflies excrete a substance with a high sugar content referred to as honeydew. Heavy infestations of aphids can produce large amounts of honeydew, thereby coating lower leaves, and giving them a shiny appearance. After mature bolls have opened, honeydew may produce sticky lint. Honeydew may also serve as a substrate for the growth of a sooty mold, which stains lint and reduces color grade. (Jeremy,2014).

Plant bugs:(tarnished plant bug and cotton fleahopper) infrequently cause problems in June and July.Tarnished plant bugs may also puncture small bolls, inflicting damage symptoms similar to that caused by stink bugs. Adults of both species of plant bugs move to cotton from wild host plants. Lygus bugs develop in wild hosts such as aster, blue vervain, and fleabane, while flea hoppers are fond of tropic croton and primrose. Both adults and nymphs feed on small squares and other tender plant parts (Jeremy,2014)

Tobacco budworm:populations have been increasing during recent years. Historically, most problems with tobacco budworms have occurred in the Coastal Plain from moths that deposited eggs during June (pre-bloom).However, in recent years, populations of tobacco budworm have been detected in early July. Tobacco budworm and bollworm are often called the bollworm/budworm complex because they will often be present in the same field, they eat the same plant structures, and they are morphologically quite similar. Before first bloom, in non-Bt cotton, fields should be treated when 15 or more small (<0.25 inch) larvae or 20 damaged squares are found per 100 plants. After first bloom, in non-Bt cotton that has not been treated previously, insecticide should be applied at 20 or more eggs, 3 small larvae, or 5% damaged squares per 100 plants. Tobacco budworms have been documented to be resistant to multiple insecticide classes, so insecticide choices are limited in non-Bt cotton (Jeremy,2014).

Bollworm (corn earworm): is a key insect pest of cotton in South Carolina because it will infest most fields in the state every year. Infestations are most likely to occur in July, after moths that have emerged from cornfields begin to deposit eggs on cotton plants. In the Coastal-Plain region, moth flights will usually begin within the period from 6 July to 20 July, with the earliest flights occurring in the Savannah Valley area. Bollworms have generally been less of a threat in the Piedmont region, where infestations generally don’t materialize before the last week in July. Insecticide applications will be triggered when the numbers of eggs, bollworms, or damage reach economic levels (economic thresholds). Scouting for eggs and hatching larvae is a responsibility of a cotton scout. After bollworm moths have deposited their eggs on cotton plants, the eggs will begin hatching in about three days. Eggs are deposited singly, generally on the upper leaf surfaces in the top six inches of the plant terminals. By mid-July or later, moths may deposit a higher percentage of eggs lower on the plants—on leaves, squares, stems, and even blooms or dried blooms (bloom tags). Scouts should check whole plants for bollworm eggs and larvae and examine the following fruiting forms on each plant: a white bloom, a pink bloom and the two smallest bolls. Remove bloom tags to look for damage on the tips of small bolls where bollworm larvae often gain entry. (Jeremy,2014).

Spider mites:are occasionally a problem in South Carolina cotton. Infestations of mites are often flared by extremely hot and dry weather conditions. Applications of insecticides for other pests may also flare infestations of spider mites by reducing the numbers of beneficial arthropods that prey upon them. Initial infestations occur from spider mites moving from wild host plants or other crops into border rows of cotton. Yellow speckling on the upper surfaces of leaves (in proximity to petiole attachment) will be the first indication of a mite infestation.As mites continue to feed on the undersides of leaves, the upper surfaces will become reddened. Early recognition of these symptoms, and spot treating infested areas, will often prevent spider mites from spreading throughout a field(Jeremy,2014)

Stink bugs:have piercing-sucking mouthparts that they use to pierce small bolls and suck sap from the seeds. Seed coats more or less collapse, and the attached lint often acquires a yellowish to brownish colored stain. Small, warty growths on the inside of a boll wall will generally mark the points of penetration. Warts typically form within 48 hours after penetration. Water-soaked lesions are signs of more recent penetrations, where warts may not have had time to develop. Warts may never develop when a stink bug penetrates the boll wall, fails to find a seed, and then quickly withdraws its beak. Furthermore, warts do not form on bolls that have reached full Size. Damaged bolls may open prematurely or become hard-locked. Usually only one or two locks will be damaged, but occasionally, if infestations are heavy, bolls may be completely hard locked. Boll damage is the main criterion used to evaluate infestations of stink bugs (Jeremy,2014)

2.2.8.1 Cotton Insect Control

Bollworm/tobacco bud worm Control

DO NOT apply a pyrethroid prior to bloom on non-Bt varieties. See Resistance Management Guidelines.Recommended insecticides for bollworm and tobacco budworm have changed due to continued insecticide resistance and control problems. Pyrethroid insecticides are NOT recommended against tobacco budworm infestations. Time applications to control newly hatched larvae (< 3 inch length). Add an ovicide when bollworm/budworm moths are laying eggs. Multiple applications on a 4 - 5 day interval may be needed. Tank-mixing pyrethroids with other insecticides may improve control of pyrethroid resistant tobacco budworms and are only recommended when the budworm ratio is no more than 20%. Change insecticide chemistry if control failures.

Thrips Control

Treat when cotton is up to a stand and thrips average one or more per plant and damage is observed.An in-furrow systemic insecticide or Gaucho seed treatment is recommended as a preventive control.

Cutworms Control

Destroying all green vegetation 21 days prior to planting reduces the likelihood of cutworm attack. Treat when cutworms are damaging stand and plant population is less than three plants per row foot. Infestations may be spotty within a field and only require treatment where damage and live cutworms are found.

Table 5. Recommended insecticides used to control cutworm

Insecticides used

	Lbs. Active Ingredient per acre	Amount Formulation per acre	Acres Treated per gal.
Cutworms			
chlorpyrifos (Lorsban 4)	0.75 - 1.0	24 - 32 ozs.	5.3 - 4
cyfluthrin (Baythroid 2)	0.0125 - 0.025	0.8 - 1.6 ozs.	160 - 80
cypermethrin (Ammo 2.5)	0.025 - 0.1	1.3 - 5.0 ozs.	100 - 25
esfenvalerate(Asana XL 0.66)	0.03 - 0.05	5.8 - 9.6 ozs.	22 - 13
cyhalothrin(Karate2.08)	0.15 - 0.02	0.96 - 1.28 ozs.	133 - 100
thiodicarb (Larvin 3.2)	0.6	24 ozs.	5.3
tralomethrin (Scout X-TRA 0.9)	0.016 - 0.020	2.28 - 2.84 ozs.	56 - 45

Aphids Control

Early-season: Parasites and predators usually control aphids on seedling cotton. If aphids are present on numerous plants and some leaves are curled along the edges, (signs of stress) treatment is suggested. In-furrow insecticides used for thrips control can suppress early-season aphids population.

Table 6. Recommended insecticides used to control aphid

Insecticide	Lbs. Active Ingredient per acre	Amount Formulation per acre	Acres Treated per gal.
Aphids			
dicrotophos (Bidrin 8)			
(early-season)	0.1 - 0.2	1.6 - 3.2 ozs.	80 - 40
(mid-late season)	0.25 - 0.5	4 - 8 ozs.	32 - 16
dimethoate 4	0.125 - 0.25	4 - 8 ozs.	32 - 16
imidacloprid (Provado 1.6)	0.047	3.75 ozs.	34

Plant bugs Control

First two weeks of squaring: Treat when plant bugs number one or more per 6 row feet or 7.5 per 100 sweeps (standard sweep net) and square loss is occurring.

Table 7.Recommended insecticides used to control plant bugs

Insecticide	Lbs. Active Ingredient per acre	Amount Formulation per acre	Acres Treated per gal.
Plant bugs			
acephate (Orthene 90S)	0.23 - 0.45	0.25 - 0.5 lbs.	-
chlorpyrifos (Lorsban 4)	0.19 - 0.25	6 - 8 ozs.	21- 16
dicrotophos (Bidrin 8)	0.25 - 0.5	4 - 8 ozs.	32 - 16
dimethoate 4	0.25	8 ozs.	16
malathion (Cythion 5)	1.25	32 ozs.	4
methyl parathion 4	0.25 -0.50	8 - 16 ozs.	16 - 8
oxamyl (Vydate CLV 3.77)	0.25 - 0.31	8 - 10.6 ozs.	16 - 12

Stink bugs:Treat when stink bugs number one or more per 6 row feet.

Table 8.Recommended insecticides used to control sting bugs

Insecticide	Lbs. Active Ingredient per acre	Amount Formulation per acre	Acres Treated per gal.
Stink bugs			
acephate (Orthene 90S)	0.72	0.8 lbs.	-
methyl parathion 4	0.5	16 ozs.	8

Spider mites

Treat areas when 50 percent of the plants are infested. More than one application on a 4 - 5 day schedule may be required if eggs continue to hatch.

Table 9.Recommended insecticides used to control spider mites

Insecticide	Lbs. Active Ingredient per acre	Amount Formulation per acre	Acres Treated per gal.
Spider mites			
bifenthrin (Capture 2)	0.06 - 0.10	3.8 - 6.4 ozs.	33 - 20
dicofol (Kelthane 4)	1 - 1.5	32 - 48 ozs.	4 - 2.6
profenofos(Curacron 8)	0.5 - 1	8 - 16 ozs.	16 - 8
propargite(Comite 6.55)	0.8 - 1.6	16 - 32 ozs.	8 - 4

Whitefly Control

Treat when 50 percent of the terminals are infested with adults. These small moth-like insects feed on the underside of leaves and readily fly when disturbed. More than one application on a 4 - 5 day schedule may be required if eggs continue to hatch.

Table 10.Recommended insecticides used to control whitefly

Insecticide	Lbs. Active Ingredient per acre	Amount Formulation per acre	Acres Treated per gal.
Whitefly			
acephate (Orthene 90S)	0.45 - 0.9	0.5 - 1 lbs.	-
methamidophos (Monitor 4)	0.25 - 0.5	8 - 16 ozs.	16 - 8

Table 11.Expected occurrence of cotton insect pests

Stage of Plant Development	Major Pests	Occasional Pests
Emergence to fifth true leaf:	Thrips, Cutworms	Aphids
Fifth true leaf to first square:	-	Aphids, Plant Bugs, Spider Mites
First square to first bloom:	Boll Weevil, Plants Bugs, Bollworm, and Tobacco Budworm	Aphids, Spider Mites
After first bloom:	Boll Weevil, Bollworm, Tobacco Budworm, Fall Armyworm	Aphids, Stink Bugs, Plant Bugs, Loopers, Beet Armyworms, Spider Mites, Whiteflies, E. corn borer

2.2.9. Diseases

Seedling diseases are presently causing great losses. They comprise the number one disease problem. The estimated loss averages 9.3 percent annually, based on a range of 5 to 18 percent since 1989. The average seedling disease loss for the U. S. Cottonbelt is only 3 percent annually for the same period. During cool, wet planting seasons, seedling diseases can become severe. Loss estimates do not include cost of replanting or losses due to lateness of replanted cotton.

A number of organisms are associated with cotton seedling diseases. The organisms include both seed- and soil-borne fungi and bacteria. The soil-borne fungi, *Rhizoctonia solani* and *Pythium* spp*.,* are the most important causes of seedling diseases in Tennessee. *Rhizoctonia solani* is the fungus most commonly associated with seedling diseases; however, during cool, wet seasons *Pythium* spp. may become more prevalent. *Thielaviopsis basicola* is being found to cause seedling diseases more frequently each year.

Symptoms

The various phases of seedling diseases include seed-rot, root-rot, pre emergence damping-off and post emergence damping-off. The term "seed-rot" is used to describe the decay of seed before germination.

Root-rot (or black-root) may occur any time after germination of the seed, but may not become conspicuous or cause severe damage until after the emergence of the seedling. Preemergence damping-off refers to the disease condition in which the seedling is killed between germination and emergence from the soil. The death of seedlings resulting shortly after their emergence from the soil is termed postemergence damping-off. The latter is referred to as "sore shin" when only stem girdling occurs. *Rhizoctonia* is usually the cause of sore shin.

2.2.9.1. Control of Disease

Seed treatments: Fungicide seed treatments give control of seed-rot and some control of preemergence damping-off. However, seed treatment gives little, if any, control of post-emergence damping-off and root-rot. Seed treatment is quite effective in controlling seed-borne diseases.

Soil treatments: Poste mergence damping-off and root-rot can be controlled to some extent by soil treatment. Three methods of applying soil fungicides are recommended in Tennessee. These methods are the hopper-box method, the in-furrow spray method and the in-furrow granule method. These methods should be used in addition to the recommended seed treatments. In fields where soil-incorporated, pre plant herbicides or granular, systemic insecticides are used, be sure to use a soil fungicide. Producers are advised to use the seedling disease point system on Table 3 to determine if fungicide application is necessary.

Hopper-Box Method: Mix recommended fungicides thoroughly with fuzzy, reginned or acid delinted seed just before planting. Mixing may be done in a container, such as a tub, or alternating layers of seed and fungicide as they are placed in the hopper. Hopper-box fungicides cannot be applied as effectively on acid-delinted seed.Application of the fungicide in the hopper-box may change the seeding rate, and recalibration of the planter may be required. Because of handling and mixing the hopper-box materials, clogging of the planter and abrasive action of the chemical, this method is not as desirable as the in-furrow methods. Although less expensive, it is also less effective; but when used properly, gives better results than seed treatments alone, especially under lower disease pressure.

In-Furrow Spray Method: This method consists of applying a soil fungicide into the seed furrow and to the covering soil during the planting operation. Application is best accomplished with two spray nozzles mounted on the planter. A cone-pattern nozzle is suggested for applying the material into the furrow behind the planter shoe. This nozzle should be placed far enough behind the shoe to prevent wetting and clogging of the seed spout. The second nozzle should be placed so as to direct the spray into the covering soil in front of the press wheel. The recommended height for the front nozzle is 12 inches above the original soil surface, with a TX6 tip and 2 to 3 inches above the soil for the back nozzle with a TX3 tip. Where space is limited and two nozzles cannot be used, substitute one nozzle with an TX8 or TX10 tip. Use 3-5 gallons of water per acre.

In-Furrow Granule Method: Granular fungicides or fungicide-insecticide combinations have given good control of seedling disease. They can be applied with applicators used for other granular chemicals and eliminate the need for additional spray equipment and water with the spray method. Effective control with granules depends on proper placement in the furrow between the seed spout and the covering device.

When using a single delivery tube, attach a flared baffle to the end approximately at a 45- to 90-degree angle to the row to obtain a 2-3 inch wide band. Granules then fall into the furrow from the seed drop to the covering device. If hill planting, a single delivery tube may be placed in the seed spout of some planters rather than using the baffle. If the delivery tube cannot be placed in the hill-drop attachment, a drill rate is required to be effective. When using either method, be sure the granules are well-dispersed around the seed and in the covering soil to avoid injury or ineffective disease control.

Cultural Practices: Certain cultural practices can help considerably in controlling seedling disease. Turning under crop residues as early as possible is suggested. Also, crop rotation with soybeans, corn, or grass will help prevent the buildup of organisms pathogenic to cotton seedlings. A well-prepared seedbed greatly enhances the chances of a good stand. Planting on beds has been shown to be of considerable value in some seasons by providing better drainage and warmer soil temperatures.

Resistant Varieties

In the future, it may be possible for growers to select a cotton variety with resistance to parasitic nematodes for use in an appropriate field. Resistance varieties are probably the best long term solution to nematode problems. Phytogen 427 WRF, Phytogen 367 WRF, ST 5458B2RF and ST 4288B2F offer cotton growers a new opportunity to manage southern root-knot (Georgia Commission, 2014).

2.3. HARVESTING

Repair Picker before Harvest

Keeping the picker in good mechanical repair and adjustment is essential for high harvesting efficiency. A good job can be done only when all working parts are in good condition, aligned and properly adjusted. In many cases, older pickers can be modernized to increase efficiency. The picker should be overhauled several weeks before harvest begins. Worn parts such as spindles, moistener pads, doffers or strippers, valves, bearings, bushings, springs, rails, etc., should be replaced and adjusted to factory specifications by trained personnel. Always use replacement parts which fully meet the manufacturer's standards.

3. Summary

- The cultivation of Cotton was first started in South Asia and South America.
- Cotton can be seen as one important thread of the globalization process in Africa
- Ethiopia is one of the origins of cotton
- The production and export of cotton in developing countries is higher than developed countries
- Ethiopia has good potential of cotton production
- For good cotton production, soil based fertilizer application and insect and disease managements are important elements

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