IMPROVEMENT OF COTTON PRODUCTION IN AZERBAIJAN

A Thesis

by

BRADEN S. TONDRE

Submitted to the Graduate and Professional School of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Steve Hague
Committee Members,	Joshua McGinty
	Gregory Sword
Head of Department,	David Baltensperger

May 2022

Major Subject: Agronomy

ABSTRACT

This study examines agronomic cotton data collected from test plots in Azerbaijan conducted by researchers from Texas A&M University and AgroCenter, an Azerbaijani consulting agency. Research was used to improve the cotton industry in Azerbaijan by focusing on improving yields, maximizing available resources and improving farming practices at the request of its government. The objectives of this study were to 1) test available varieties sourced from neighboring countries and select for high yields and fiber quality, 2) evaluate the effects of various levels of nitrogen fertilizer rates on cotton yield, crop maturity, and fiber quality, and 3) measure how effectively cotton could be defoliated and how the various treatments would impact fiber quality. There was minimal variety by location interaction within the country and high-quality cotton fiber can be produced. Cotton varieties should continue to be tested, and selected based on yield, fiber quality, and earliness of maturity. Fertilizer trials had minimal treatment by location interaction and the current rate of 200 kg ha^{-1} of monoammonium phosphate provided highest yields. Treatments containing the highest rate of Baystar (thidiazuron and diuron) and Son Final (ethephon and cyclanilide) achieved the desired level of defoliation. Defoliation trial results support the strategy of using split applications of defoliants.

DEDICATION

I would like to dedicate this thesis to my amazing parents and sister for their constant support throughout my college experience, and to my granny for her encouragement and moral support.

I want to pay homage to my Algerian ancestors who traveled the Silk Roads as merchants in the 13th century.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Hague, for all his help and for giving me the opportunity to participate in this project involving international agriculture. Thanks also to my committee members, Dr. McGinty and Dr. Sword for their help.

I want to thank the people involved with the Texas A&M Cotton Improvement Lab for their help in harvesting and ginning samples and thanks to Caitlin Lakey, Graduate Research Assistant, who assisted with harvest and research.

Finally, thanks to Mr. Uzeyir Topchibashev of AgroCenter for his assistance in managing research plots during the growing season and for planning the itinerary during our visits to Azerbaijan. Because of him, I was able to learn about the country, its history, and its agriculture.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This graduate research project was conducted under the guidance of Dr. Steve Hague, Dr. Joshua McGinty, of the Department of Soil and Crop Sciences, and Dr. Gregory Sword, of the Department of Entomology. This project also was made possible with the assistance of Texas A&M graduate student, Caitlin Lakey. I also would like to thank the student workers at the Cotton Improvement Lab for ginning my fiber samples from College Station, Texas. A special thank you to the many Azeri workers who maintained the research plots throughout the season.

Funding Sources

This work was made possible by the funding provided by 'AgroCenter', with the supervision of Uzeyir Topchibashev.

NOMENCLATURE

AFIS	Advanced Fiber Information System—provides details about fiber maturity, fineness, short fiber content, neps, and length
AIOJSC	Amelioration Irrigation Open Joint Stock Company
DUMA	Legislative body (assembly) of Russia
ENP	European Neighborhood Policy
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GLASNOST	Policy or practice of more open government in the Soviet Union
HECTARE	A metric measure equal to 10,000 square meters (2.471 acres)
IFAD	International Fund for Agricultural Development
MANAT	Azerbaijan currency (manat = 0.59 U.S. dollars)
MKT	Agricultural organization headquartered in Baku, Azerbaijan
NMP	Net Material Product
PERESTROIKA	Openness in government in the Soviet Union
QUINTAL	A hundredweight
SERICULTURE	The production of raw silk by raising silkworms
UNESCO	United Nations agency that promotes the exchange of ideas
WTO	World Trade Organization
WUA	Water User Association

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

1. INTRODUCTION

In an effort to develop more efficient methods to raise productive crops, the government of the Republic of Azerbaijan, in partnership with "AgroCenter," an Azerbaijani consulting agency, is attempting to reduce rural poverty, provide food security, and reintroduce industrial crops, such as cotton, to support the Azerbaijan economy. To accomplish this, it enlisted the help of Texas A&M University researchers and extension specialists to conduct agricultural research, education, and reporting to enhance cotton productivity and profitability.

As one of the 15 states of the Union of Soviet Socialist Republics (U.S.S.R.), Azerbaijan had a long history as a large cotton producer and was acclaimed by the Soviet states for being one of the leaders in cotton production among all of its states. However, its fame as a top cotton producer waned, and the oil and gas industries became more important to the economy. After Azerbaijan became independent in 1991, the cotton industry began to decline. That was about the time that the Azerbaijan government began the redistribution of farmland. In 2005, 112,000 hectares were harvested, but by 2009, Azerbaijan cotton production declined to 21,000 hectares (Hague, personal communication, 9 July 2019).

The push to reestablish cotton as an agricultural cash crop is vital to Azerbaijan's future. In 1999, it was one of the 34 countries experiencing shortfalls in food supplies and required emergency assistance from the Food and Agriculture Organization of the United Nations (Azerbaijan, n.d.). With food security issues alleviated, the government is now taking steps to restore cotton to its previous productivity, diversify the economy, and strengthen the agriculture sector, saying that “[N]ew technology and Azerbaijan’s favorable climate and soils can attain the high levels of cotton production it once had.” (Azerbaijan, n.d.) The objectives of this project to help Azerbaijan meet its goal of improved cotton production were to: 1) identify cotton varieties best suited for Azerbaijan; 2) determine an optimal application rate of nitrogen fertilizer that provides the highest yield; 3) determine an optimal rate of defoliants and boll openers to reduce the amount of foliage being harvested and increase the number of bolls that are open at the time of harvest; and 4) compare results from the Azerbaijan trials with trials conducted at College Station, Texas to determine how the information from field trials between the two locations differed.

2. LITERATURE REVIEW

A knowledge of Azerbaijan history helps to understand how it shaped the nation. Because Azerbaijan culture has been influenced by countless dynasties, religious beliefs, languages, conflicts, and wars, the people have an innate sense of distrust. Since ancient times, Azerbaijan has been invaded repeatedly by neighboring countries and kingdoms for control and exploitation of its oil, farmland, and other natural resources. This eroded confidence in its system of government and leaders as those institutions failed to keep the country secure. Throughout history this has continuously affected their society and perspective (Emirdirek, n.d.).

Many empires and cultures influenced Azerbaijan as its land was fought over, conquered, and ruled during countless insurrections and wars that occurred throughout the centuries. Its people were descendants of the Caucasian Albanians who once belonged to a large kingdom whose subjects were taken over by other cultures following wars with the Romans, Persians, Arabs, Mongols, and Turks. Persians established the Persian language by 1100, and Azerbaijan was converted to Islam by conquering Arabs around 700-800 A.D. (Wilson and Rainey, 2015). At the beginning of the 12th century, the people became “Azerbaijani Turks” when the Oghuz Turks crossed the Caspian Sea and began arriving from Turkmenistan during the Mongol migrations. When the Oghuz Turks moved farther west and founded modern-day Turkey in the 16th century, the modern Azerbaijani language and culture, which are Turkic, had been well established (Wilson and Rainey, 2015).

About the same time, the Safavids, a Persian dynasty, invaded and began ruling Azerbaijan, and the Azerbaijani language became important throughout the empire. When the Safavids converted the Azerbaijan and Iranian state religions to Shiite, they also attempted to forcibly convert Sunni Afghans (Sunnism is the branch of Islam practiced by all countries surrounding Azerbaijan), but the Afghans resisted. After war broke out over the Safavid attempt at Shiite conversion, the Safavid dynasty collapsed. The Russians, Ottomans, and Uzbeks invaded Persian possessions after the Safavids were destroyed in 1736 (Wilson and Rainey, 2015).

The Persian Dynasties of Afshar and Zand ruled the territory for a short while (from 1736 to 1747), then independent Turkic Khanates (tribes) took over until the Qajars became rulers in 1789. The Qajars were of Azerbaijani descent and gave prominence to Azerbaijani religion and culture; however, the territory was annexed away from the Qajars during the Russian Revolution (1813-1828) because Russia wanted access to the region to attack the Ottomans and the Persians (Wilson and Rainey, 2015). Conflicts soon began with the Persians and, after Russia defeated the Persians, all Azerbaijani states were incorporated into the Russian Empire. In 1828, Azerbaijan was divided between Russia and Persia (now Iran) by the Turkmanchay Treaty. The northern section of historical Iran became a part of Russia, and the southern part went to Persia. Russia then dominated almost all of the Northern and Southern Caucasus (Wilson and Rainey, 2015; Azerbaijan Profile, 2018).

While the tsar’s interest was consumed by the Russian Revolution, he allowed Khanates in Azerbaijan to rule themselves until the 1870s. The expanded development of Azerbaijan's oil reserves began then, as Russia was increasing economic development in the Caucasus. This development brought about huge misunderstandings between the rulers who were Christian European, the tycoons who were westerners, and the predominantly Muslim population. When the Russian government became involved, it tried to stir up more distrust among all the various groups. Thus, during the revolutions of 1905 and 1917, the Azeris and Armenians fought the Russians and capitalists as they were also fighting between themselves (Wilson and Rainey, 2015; Azerbaijan Profile, 2018).

Following World War I, Azerbaijan's people decided to become an independent republic, and in 1919-1920, it briefly had independence as an anti-communist government. However, that failed to last because Russia, afraid of losing the Baku oil fields, led an invasion, and Azerbaijan was taken over by the Bolshevik regime. A Soviet government was established and, in 1936, Azerbaijan became a full republic of the U.S.S.R. (Wilson and Rainey, 2015; Emirdirek, n.d.; Ibrahinov, 2016; Azerbaijan Profile, 2018).

In 1991, after the collapse of the Soviet Union, the Azerbaijani parliament voted to restore independence and Azerbaijan became free. Azerbaijan signed what it called the "Contract of the Century" with eleven major international oil companies in 1994 for the exploration and development of Azerbaijan's offshore oil fields (Azerbaijan Profile, 2018).

2.1. Azerbaijan's Place on The Silk Roads

Azerbaijan had a unique position in the Middle East, as it was the only convenient land route between Europe and Asia. It has connected civilizations since ancient times and played a significant role for the Silk Roads that connected Central Asia and the West. The roads made it possible for merchants to trade between kingdoms and empires as their routes increased. From numerous Egyptian-Roman artifacts that were uncovered there, it was determined that Azerbaijan was along the Silk Roads trade routes in the 5^{th} century B.C. (Ghosh and Zhaowen, n.d.). During the 1st century B.C., Azerbaijan's Silk Roads were used to link the Roman Empire and the Han Dynasty that ruled China from 206 B.C. to 220 A.D. The routes were established when Wu, the Chinese emperor, dispatched his envoy to Central Asia to bring back information about western peoples and lands. This led to China's trade with the Middle East and Europe. However, the movement of goods along those trade routes dates back even further (Ghosh and Zhaowen, n.d.; Silk Road, 2019).

The exchange of goods, ideas, and cultural practices have been traced back to the third millennium B.C. and helped to develop cultures across the Old World. During the first and second centuries B.C., the principal route for what would later be known as the Silk Roads lay across Azerbaijan. Then it was usually called "Strabon" (after the map maker who named it) (Azerbaijan and the Silk Road n.d.).

This busiest way started from China and India, crossed Central Asia, crossed the Uzbal River, which flows into the Caspian Sea, and then crossed the territory of Azerbaijan. It then split into two roads. One road led upstream to the Kura River toward

Colchis and Iberia, and the other route turned and followed the western coast of the Caspian Sea across Derbent and the Caucasian steppes (Azerbaijan and the Silk Road, n.d.).

Silk Roads traders considered Azerbaijan to be the safest of the entire Road. Georgia, Iberia, and Colchis that followed after, were politically stable states that provided the functioning of the route. Therefore, that section of road was durable, stable, and one of the major destinations of merchants in antiquity (Azerbaijan and the Silk Road, n.d.). Numerous ancient Azerbaijan cities were founded along the two branches of the "Strabon way." In the early Middle Ages, Azerbaijan, particularly its capital, Barda, became an important Silk Roads center and was known as the world's greatest trading center along one of the roads' branches. Until the 10th century, Barda had the distinction of being one of the greatest craft centers in all the Middle East and Transcaucasia (Azerbaijan and the Silk Road, n.d.).

Much of this Silk Roads' northern route involved water transportation, both via the Caspian Sea and a network of rivers which was cheaper and sometimes more efficient than land routes. The Bay of Baku was known as one of the best Caspian harbors because it was well sheltered from the region's fierce winds, and it attracted heavy traffic to the Azerbaijani coast (Ghosh and Zhaowen, n.d.). Silk Roads routes also led to ports on the Persian Gulf where goods were then transported up the Tigris and Euphrates Rivers where they were also connected to ports along the Mediterranean Sea. Those goods were shipped to cities throughout the Roman Empire and Europe (Silk Road, 2017).

Since they served as the largest means of commerce in the ancient world, the Silk Roads shaped cuisines throughout history by spreading agricultural crops and crop varieties, as well as by adding the rich spices of the East to enhance the bland diets of Europe. Chinese agriculture became influential, as the Silk Roads played a key role in spreading rice (*Oryza sativa*) cultivation, making a huge impact on the daily lives of many people. As rice cultivation spread, countries became the beneficiaries of early globalization when rice became an important economic crop for export (Li Xinsheng, 2017).

While establishing the foundation for Chinese civilization, Chinese agriculture played a role in world history as the Silk Roads were used to export agricultural products and culture to far-off lands (Spengler, 2017). Soybean (*Glycine max*) and tea (*Camellia sinensis*) growing cultivation practices were carried along the Silk Roads and soon began to enrich people's diets (an outstanding example is the long-standing Azerbaijani custom of serving tea with every meal). Silk became an important textile to the world as it lent its name to the Silk Roads. "China [contributed] four important 'agricultural inventions'--rice, soybeans, tea growing, and sericulture . . . to humanity's survival and development." (Li Xinsheng, 2017) It can be argued that these agricultural crops equal or surpass other world-changing inventions such as the compass, gunpowder, papermaking, and movable-type printing (Li Xinsheng, 2017). As crops spread through Central Asia, farming in Europe and Asia changed. An example of that change is the introduction of crops "such as millet (*Pennisetum glaucum*) to Europe and wheat (Triticum) to China." (Spengler, 2017) Once people were introduced to a new crop, they soon became interested in growing and using it, and that was facilitated by the Silk Roads.

The Silk Roads routes had trading posts, markets, and designated transportation that were used to transport, distribute, and store goods, as the routes extended from Greece to modern-day Iraq, Afghanistan, Mongolia, and China. European and Roman merchants and traders began to call this network the "Silk Roads" because of the popularity of the Chinese silk traded on it (Silk Road, 2017). Regardless of the Silk Roads' name, silk was not the only product exported from East to West that changed European culture. So many things, such as fruits and vegetables, livestock, grain, leather and hides, tools, religious objects, artwork, precious stones, and metals, as well as language, culture, religious beliefs, philosophy, and science, were traded (Silk Road, 2017). Some commodities had lasting impacts on western culture and history.

2.2. Development Along the Silk Roads

Azerbaijan continued as a region of commerce throughout the Middle Ages. As caravans on the Silk Roads crossed there, merchants stopped to buy, trade, and sell, quickly placing Azerbaijani wares into the Silk Roads network (Silk Road, 2017). Azerbaijani artisans offered various useful merchandise which they sold to many Silk Roads merchants, including jewelry, ceramics, wooden goods, several types of musical instruments, weaponry, locally produced silk goods, brightly colored and beautifully designed, hand-made carpets, and copper items such as kitchen ware, trays, candlesticks, and astronomical devices. In turn, oil, jewelry, salt, mercury, alum, wool, flax, cotton, dyes, and medicine were some of the goods that Azerbaijan traded to Europe (Azerbaijan and the Silk Road, n.d.).

As the number of Azerbaijan cities located on the Silk Roads increased between the 14th and 18th centuries, trade relations also increased, bringing about an exchange of cultural values among additional countries. As the Volga-Caspian Sea waterway developed, cities grew up and trade was increased with Russian and English merchants (Silk Road, 2017). This brought about the development of transportation centers and warehouses that stored goods from Europe and the Orient. These warehouses drew merchants from Russia, Europe, Turkey, Central Asia, and the Far East, and caravanserais, which were small hotels, grew up in all of Azerbaijan's major cities to accommodate travelers. Local governors received large payments for approving the construction of guesthouses and small prayer monasteries near the temples to accommodate religious pilgrims (Azerbaijan and the Silk Road, n.d.).

As the Silk Roads' network expanded, their influence grew to affect learning, religion, and culture. Among the travelers of the Silk Roads were intellectuals and scholars, such as mathematicians, astronomers, philosophers, and poets who stimulated and encouraged learning, expanded the role of the arts, and exchanged new ideas (Ghosh and Zhaowen, n.d.).

Among those spreading religious influences throughout history was the prophet, Zoroaster who, according to legend, was born and died in Azerbaijan. During ancient times, Zoroaster spread religious teachings, called Zoroastrianism, which were widely followed. One of his most important contributions to Azerbaijani culture is the yearly religious festival, *Nowruz*, which translates into "new year". It is rooted in Zoroastrianism and is celebrated on the day of the vernal equinox. It continues to be celebrated in Azerbaijan and surrounding countries each year (Emirdirek, n.d.). A Persian dynasty that originated in a Shiite religious order, Safavuiyya, was founded in Azerbaijan by Safe ad-Din and served Kurds and Azerbaijanis (Wilson and Rainey, 2015).

Along with Azerbaijan's small Zoroastrian community, there have also been Christians, Muslims, Hindus, Jews, and Parsees who spread their religious influence (Ghosh and Zhaowen, n.d.). In the 4th century A.D., Azerbaijan became one of the earliest regions to follow Christianity, then in the 7th century, after the Muslim conquests, it was converted to Islam. Since ancient times, there have been Jewish communities in Azerbaijan, and a Hindu community that has existed since the Middle Ages is thought to have been established by Silk Roads merchants from India who settled in Azerbaijan. Baku was called "The Land of Fire" by the Parsees who worshiped fire. Because oil seeped to the ground's surface in the area and often caught fire, the Parsees considered it a miracle, thus, Baku was a holy city to them (Ghosh and Zhaowen, n.d.).

Travelers besides merchants and pilgrims were also using the Silk Roads. In 334 B.C., the armies of Alexander the Great, King of Macedonia, traveled on the Royal Road, which was ultimately incorporated into the Silk Roads, to conquer the Persian Empire and expand his kingdom (Silk Road, 2017). Likewise, in 1271, Marco Polo, an explorer from Venice, used the Silk Roads to travel by camel caravan from Italy to

China by overland routes to reach Xanadu, the palace of Kublai Khan, the Mongolian ruler. He remained there over twenty years and returned on the Silk Roads routes. Marco Polo wrote about his journeys along the Silk Roads in *The Travels of Marco Polo*, a book that gave Europeans a glimpse of Asian culture and through which they were introduced to the wonders of the East, such as paper currency, coal, asbestos, and other things unknown in Europe (Silk Road, 2017).

2.3. Cotton Was Traded Along the Silk Roads

Although the Silk Roads were famous for trading silk, they also were used in trading cotton. Trading cotton along the Silk Roads impacted the economies, religions, and politics of involved trading partners, which, in turn, made cotton an important international commodity (Kaufman, 2016). Cotton was first grown around 3000 B.C. in the Indus Valley in Pakistan and was first woven and spun to make cloth in the Indus Valley (Dunn, 1952). Cotton fabric was introduced to China and Europe by way of the Silk Roads where it soon became more popular than silk. Archeological excavations have established that cotton was growing in Azerbaijan in the 5^{th} and 6^{th} centuries A.D. (Dunn, 1952). Historians discovered that cotton was grown in the Middle East as early as 350 B.C., and these cottons, planted around the Persian Gulf, were Asiatic types (now known as *Gossypium herbaceum*) which were probably imported from India (Dunn, 1952).

As people were becoming familiar with growing cotton and using it throughout the Silk Roads, Indian cotton was introduced as a crop in China. The cotton grown in

China was considered to be lower in quality than Indian cotton, prompting the Chinese to seek imports from India (Kaufman, 2016). There were several reasons for the increase in demand for cotton. A main reason was its use for religious purposes. Burmese Buddhists were replacing the silk coverings of statues for religious services with cotton coverings and, due to their non-violent beliefs, Buddhists were forbidden from injuring any creature, even the silkworm used in making silk. Political implications came from the Mongols who had a law that required some provinces to pay a tax on cotton, and laws also forced land-holding peasants to devote a portion of their cropland to cotton production (Kaufman, 2016). After the Romans learned about using it, cotton production spread over a much wider area and connected people from east to west throughout the Silk Roads.

To the Romans, cotton was a luxury, and they used it to create magnificent, colorful garments and decorations. According to Valerie Hansen, author of *The Silk Road: A New History*, "Silk was the primary source for fine textiles, clothing, and decorative purposes but was easily replaced with cotton, if necessary, which was much cheaper." (Hansen, 2015) Cotton was an effective fiber for replacing silk and was used in combination with silk to weave a fabric that had the look of silk at a much lower cost. This weaving process, called "mulham", was a way of making fabric that incorporated silk and cotton, but it used less silk. The silk threads formed the top surface of the fabric while cotton thread was interwoven on the underside and was visible only from the fabric's underside, giving the finished product the appearance of fine silk. (Kaufman, 2016).

2.4. History of the Russian Empire

Russia fought many wars against neighboring countries and often conquered them. After a conquest, it took possession of the country, making it a part of Russia. Since the 16th century, all Russian governments practiced this expansionist policy as it added territories to its empire (Mosely,1948). Whether it occurred by conquest, annexation, territorial claim, or treaty, the country grew and became more powerful, causing great concern among other nations (Mosely, 1948).

At the same time, the culture and outlook of Russia were extremely medieval. It was centuries behind Western Europe in economic development and technology and was viewed as undeveloped and backwards (Russian Revolution, 2009). In addition, it practiced serfdom, a type of feudalism, which forced landless peasants to serve the land-owning nobility well into the nineteenth century, while most of Europe had abolished it in the Middle Ages. In 1861, Russia finally abolished serfdom, but peasants were still bound to the land through continuing labor obligations (Russian Revolution 2009).

In the years preceding the Russian Revolution in 1917, Russia was involved in four successive wars, including The Crimean War (1854-56), The Russo-Turkish War (1877-78), The Russo-Japanese War (1904-05, and World War I (1914-18). These wars caused great unrest among the Russian people (Fernholz, n.d.). In addition to the wars, there were three factors that brought about the revolution. First, there were the citizens who faced chronic hunger because of food shortages; the country was also dealing with a population increase of 30 million people in less than 30 years (Fernholz, n.d.).

There was an increase in the industrial working class in the major cities, bringing about low wages and destitute living conditions. Lastly, the tsar showed a lack of interest in his duties. He did not understand how industrialization and nationalism were affecting Russia and did not care about the struggles of the people because he believed that he was chosen by God to be their ruler (Fernholz, n.d.).

2.5. The Russian Revolution and The Breakout of World War I

The Russian Revolution of 1905 began following a long period of protests and tumult in Russia. While having the tsar's power imposed on them for many years, the people endured increasingly bad economic conditions, and there was unrest in both the rural areas and urban centers. This led to several divisions within political groups that had been disturbed by the tsar's incompetent handling of the Russo-Japanese War. On 22 January 1905, an insurrection called "Bloody Sunday" began when workers were fired upon by troops as they marched in a peaceful demonstration to petition the tsar for increased food rations. About 1,000 people were killed or injured (Russian Revolution Timeline, n.d.). This was followed by months of strikes, riots, and peasant uprisings that forced the government to agree to elect a Duma (assembly) to bring about reform. Later, when the tsar limited the power of the Duma, the government also tried to suppress the revolutionary movement (Russian Revolution, 2009).

World War I began in 1914. Most groups in Russia, with the exception of the Bolsheviks, supported the war. However, a succession of failed military campaigns by Russia, poor troop morale, food shortages, and the suffering of the people brought about rebellion, and soon almost no one supported the war. World War I was disastrous for the

Russians because they had food and fuel shortages, high inflation, and there were huge war casualties (Russian Revolution 2009).

There were two Russian Revolutions in 1917. The first one (in February) overthrew the imperial government, and the second (in October) enabled the Bolsheviks to take power (Russian Revolution Timeline, n.d.). The February Revolution began on March 8, 1917, as industrial workers in the cities were striking for increased food rations, and Russian soldiers refused to stop them. Tsar Nicholas II, while trying to stop the strikers, dissolved the Duma. When the members of the Duma refused to follow the tsar's orders to step down, protesters took to the streets calling for the abolition of the Russian monarchy. Many protesters were killed by police and troops. The tsar, unable to resist any longer, abdicated the throne on March 15, 1917, and a socialist provisional government attempted to replace the tsarist government and continue the war (Russian Revolution Timeline, n.d.). With little support, it assumed power and called for general amnesty, civil liberties, and an elected constituent assembly. Tsar Nicholas II and his family were imprisoned and later executed by the Bolsheviks in July 1918. They were murdered due to fear that if they lived, they would be a symbol for the anti-Bolshevism movement (Russian Revolution, 2009; Fernholz, n.d.).

Meanwhile, Vladimir Lenin returned to Russia in 1917 from exile in Finland (Fernholz, n.d.). Permission was granted by the German government for Lenin to cross Germany traveling in a sealed train. By helping Lenin return to Russia, the German government hoped to disrupt the Russian war effort (Fernholz, n.d.). Lenin's party broke into two factions, the Bolsheviks, led by Lenin, and the Mensheviks. With the October

Revolution, the Bolsheviks organized a coup d'état and captured government buildings in Petrograd, Russia's capital. A new government was soon formed with Lenin as its head. Thus, Lenin became dictator of the world's first communist state, making it possible for the rise of the Soviet Union (Russian Revolution, 2009).

By November 1917, the Bolsheviks had taken control of Petrograd and a Civil War broke out (Russian Revolution, 2009). Lenin issued The Decrees on Land, providing for the abolition of private property and the redistribution of the land among the peasants. He also called for censorship while issuing The Decree on the Press, abolishing the "Bourgeois" press. In December 1917, the Bolshevik regime mandated that each person in the country could receive one-fourth pound of bread per day while bread and flour were being sold openly at excessive prices (Russian Revolution Timeline, n.d.).

On 3 March 1918, Russia ended its involvement in World War I with the Brest-Litovsk Treaty. During the war, the Bolsheviks had lost a large portion of the population, one-third of its railroads, one-half of its industry, three-fourths of its iron ore supply, nine-tenths of its store of coal, and most of its food supply (Russian Revolution Timeline, n.d.). In their final battles, they were forced to retreat because they were outmanned, had used up their supply of munitions, and almost one million of their troops had been captured. This created massive unrest and protests in Russia. With the signing of the Treaty of Versailles on 28 June 1919, following long negotiations at the Paris Peace Conference, World War I was terminated (Russian Revolution Timeline, n.d.).

Vladimir Lenin had studied the writings of Karl Marx, a German philosopher, who believed that capitalism would only disappear with a revolution (Fernholz, n.d.) Prior to the Russian Revolution of 1905, Lenin had organized a socialist group. He was immediately arrested and sent into Siberian exile since any activity that opposed the government was illegal in Russia. When he was freed from Siberia, Lenin went to Switzerland. From exile, he controlled the Bolshevik committee and convinced them to plan for an armed uprising. This uprising occurred with the October Revolution and the Bolsheviks went on to gain the majority in the congress and declare Lenin as their leader (Fernholz, n.d.).

2.6. The Development of Azerbaijan's Oil Industry

The Baku oil fields opened with the drilling of the world's first oil well in 1848-49 (Azerbaijan Profile, 2018). By 1901, the town of Baku had grown and attracted Russians, Armenians, and a few westerners to Azerbaijan (Azerbaijan Profile, 2018). The Armenians, who ran most of the petroleum companies, and many rural Azeris who came to the city to work in the refineries, joined the socialist movement and Bolshevism (the precursor of communism) took root. The two groups failed to get along because the Azeris were less skilled than the Armenians and earned lower wages; this led to ethnic tensions, religious differences, and conflicts. Differences in skills, education, and wages played a large part in clashes between the Azerbaijanis and Armenians. As they were interspersed with a mixed population of Russian, Armenian, and Muslim workers who had been indoctrinated into socialism and trade-unionism, there was growing disorder (Emirdirek, n.d.).

Thirty years after the first well was drilled, the Nobel brothers set up an oil production company. That was about the same time the tsar invited Westerners, such as the Rothschilds and the Nobels, to apply new oil technologies in Azerbaijan. Soon Baku was the beginning of the world's first oil pipeline, and the world's first oil tanker, the Zoroaster, was being constructed by the Nobel family to carry Azerbaijan oil. Because of the need to transport oil, the Trans Caucasus Railroad was built, and it not only could haul oil, but also ensured that Russian troops could defend the oil fields in Baku (Wilson and Rainey, 2015; Azerbaijan Profile, 2018).

2.7. Azerbaijan's Place in World War II

World War II fighting never reached Azerbaijan soil. However, its extensive oil reserves made the Nazis prioritize it for invasion. Oil was essential to fuel Germany's war effort; additionally, the Nazis wanted to cut off the Soviet's ability to fight (Hague, personal communication, 9 July 2019). In September 1942, a German army numbering more than 500,000 men set out to capture the Caucasus oil fields, but the Nazi plans to capture the oil fields was halted at Stalingrad where they met stiff opposition (Hague, personal communication, 9 July 2019). In what has been called mankind's bloodiest single battle in history, sixteen Soviet divisions defended the city. After two months of intense combat, most of the city was held by the Germans ("The Battle of Stalingrad", 2020). However, the Soviets continued to fight. Two Soviet forces eventually encircled German troops and, after almost six months, the Axis invading force was soundly defeated. The Soviets began to move westward and continued on the offensive for the rest of the war (Ghosh and Zhaowen, n.d.).

2.8. Azerbaijan's Recent History

Azerbaijan history is extremely turbulent due to it being invaded, inhabited, and ruled by many different peoples. At various times throughout its past, it was affected by Christian, pre-Islamic, Islamic, Persian, Turkish, Mongol, and Russian cultures. Both Azerbaijanis and Iranians are Shiite Muslims, however, Azerbaijan's liberal Muslim community often clashes with the religious fundamentalist ideology of Iran, which is ultra conservative (Wilson and Rainey, 2015; Emirdirek, n.d.).

In 1918, following the Russian Revolution, Azerbaijan's leaders formed an independent republic and anti-Communist government. However, that failed to last because the Soviet Union, afraid of losing the Baku oil fields, invaded Azerbaijan in 1920 and the Bolsheviks took over the government. Azerbaijan became a constituent republic of the Soviet Union in 1922. In 1936, it became a full republic of the Soviet Union and was influenced by Russian culture. In 1991, Azerbaijan regained its independence after the Soviet Union's dissolution (Wilson and Rainey, 2015; Azerbaijan Profile, 2018).

2.9. Impact of The Nagorno-Karabakh Conflict

The Nagorno-Karabakh region occupy approximately 13 percent of Azerbaijan's territory. Nagorno-Karabakh is a breakaway republic allied with neighboring Armenia that is defacto independent but unrecognized by the international community (Wilson and Rainey, 2015). There has been bloody fighting in the Nagorno-Karabakh region between ethnic Armenians and Azeris because the Armenians, who made up a majority of the population, wanted unification with Armenia. Tensions between Azerbaijan and

Armenia have existed since the late 1980s (Wilson and Rainey, 2015). The Armenian military occupied Nagorno-Karabakh and the occupation has continued for over 30 years. Ethnic tensions worsened and there were charges of ethnic cleansing against the Armenians. The Soviet Union tried to help the situation by promoting Heydar Aliyev, a native of Azerbaijan, to head the government in 1969, and he became head of the Communist Party. After Aliyev's standing with the Soviets rose and he left for Moscow in 1982, ethnic strife escalated between the Armenians and Azerbaijanis again, and Nagorno-Karabakh became violent (Ibrahimov, 2016). After Nagorno-Karabakh declared itself an independent republic, Nagorno-Karabakh and Armenia-Azerbaijan's hostilities developed into a full-scale war that lasted six years (Ibrahimov, 2016). The repercussions of that war continue to have major implications for Azerbaijan in the form of 860,000 Internally Displaced Persons and 500,000 people in need of humanitarian assistance. Today, many of those displaced people live in primitive huts and abandoned railroad cars (Wilson and Rainey, 2015; Qamar, 2013; Ibrahimov, 2016).

By 1994, Azerbaijan had lost control of Karabakh, and there was a ceasefire. Nagorno-Karabakh still claimed to be an autonomous republic, and continued to seek to become part of Armenia, while Azerbaijan continued to call for Nagorno-Karabakh to be recognized as Azerbaijani territory. In a turn of events, on 27 September 2020, Armenian and Azerbaijani troops began a conflict over Nagorno-Karabakh that lasted for 44 days (Armenia/Azerbaijan, 2021). The two countries took advantage of the world's inattention due to the world-wide Coronavirus pandemic and, according to Marie Struthers, Director of Amnesty International for Eastern Europe and Central Asia, Armenian and Azerbaijani forces repeatedly used inaccurate and indiscriminate weapons on populated civilian areas and killed civilians, including multiple children and older people, injured hundreds more, and destroyed homes and infrastructure (Azerbaijan/Armenia, 2021). She added that they had violated the laws of war and showed disregard for human life (Azerbaijan/Armenia, 2021).

In November 2020, a ceasefire agreement was reached between Russian President Vladimir Putin, Azerbaijani President Ilham Aliyev, and Armenian Prime Minister, Nikol Pashinyan, to end the Nagorno-Karabakh conflict. President Putin reported the deaths of almost 5,000 people due to the armed conflict (Armenia, Azerbaijan, and Russia, 2020). He added that Russian troops would be on guard to prevent violence. The agreement was based upon Azerbaijan keeping what it captured in Nagorno-Karabakh, while Armenia promised to leave other areas soon. According to the BBC, the conflict ended as a victory for Azerbaijan (Azerbaijan/Armenia, 2021; Wilson and Rainey, 2015).

2.10. Cotton's Effect on Azerbaijan's Politics

Following a mandate from the Russian government to find alternative industries to diversify its economy, President Heydar Aliyev was both politically and economically successful when he pushed for more cotton production in Azerbaijan. Cotton reached peak performance under his leadership. According to a speech given by his son, President Ilham Aliyev, at a 2019 government meeting of cotton growers, cotton surpassed all expectations under Heydar Aliyev's leadership (President Aliyev chairs meeting, 2019):

. . . in 1969 when Heydar Aliyev was elected first secretary, cotton was sown on an area of 200,000 hectares in Azerbaijan and about 300,000 tons of crop was harvested, i.e., the average yield was 15 quintals (3,300 pounds). In the early 1980s, productivity approached 30 quintals and was even [more] (sic) than 30 quintals for several years. Cotton harvesting was stable at about 800,000 tons. In 1981, this figure increased to 1 million tons (President Aliyev chairs meeting, 2019).

Due to his success in Azerbaijan's agriculture sector, Heydar Aliyev went to Moscow in 1982 where he became a full member of the Soviet Politburo (Azerbaijan Profile, 2018). As his political power grew, he was the highest-ranking Azerbaijani in the history of either the U.S.S.R. or tsarist Russia. 'Glasnost', also known as openness, was a policy of a more open government initiated by President Mikhail Gorbachev in 1985 (Wilson and Rainey, 2015). It was a period of great political and economic upheaval in the U.S.S.R (Wilson and Rainey, 2015). As the Soviet economy and political system collapsed, Aliyev left the Politburo and the Council of Ministers and returned to Azerbaijan where he was elected president in 1993 and re-elected in 1998 (Azerbaijan Profile, 2018). There were huge changes in Azerbaijan because of the reforms demanded by the Soviet Union. When Aliyev resisted the political reforms, he was banished from politics by the Gorbachev administration. In 2003, Heydar Aliyev appointed his son, Ilham, as prime minister and, later in the year, Ilham Aliyev was elected president of Azerbaijan. Ilham then appointed his wife, Mehriban Aliyeva, as vice president, and they continue to hold office today (Wilson and Rainey, 2015).

2.11. History of Azerbaijan's Agricultural Production

When it became independent in 1991, Azerbaijan's agricultural sector needed major restructuring. Some of the problems confronting farmers were:

- Low agricultural prices.
- The old collective farm system discouraged innovation.
- Soviet-era agricultural machinery was inefficient.
- Farm programs were poorly managed.
- The Soviet-era irrigation system was inefficient and inadequate (van Berkum, 2017).

Farmers faced challenges just getting crops planted. The use of fertilizers and agricultural chemicals had fallen; in fact, there was little production of domestic fertilizers. Seed was inadequate and in short supply, affordable credit was unavailable, which hindered expansion, and the sparse amounts of machinery available was badly in need of repair. Because of disrepair, the canals and pipelines wasted millions of gallons of water yearly, as they were being used to irrigate over 1 million hectares of cultivated land (van Berkum, 2017).

After a huge surge in cotton production in the early 1980s, Azerbaijan's yields dropped to record lows in the early 1990s. This was likely due to soil fertility depletion and excess salinity that can adversely affect crop productivity unless adequate inputs are maintained. Maintenance on the irrigation system would also have helped farmers confront production limitations (van Berkum, 2017).

In 2015, the number of people employed in agriculture, forestry, and fishing was 1.7 million, but only 46,000 were working in agriculture, an extremely low number. The numbers likely indicate that most of the 1.7 million peoples' status was probably self-employed, employer, or unpaid family worker (van Berkum, 2017). Farmers' incomes averaged 246 manat per month, slightly lower than half the country's average, showing that agricultural incomes are quite low compared to incomes from other occupations (The State Statistical Committee, n.d.). Using current exchange rates that converts to about $145 U.S. dollars per month.

2.12. Government Policy

As agricultural production in Azerbaijan declined and the poor state of the agricultural sector continued downward, the government was forced to take measures to support it. In late 2017, government policies were put into place to support farmers, such as hectare payments, input subsidies, and tax exemptions, such as the one exempting farmers from taxes, and producers began to receive a premium of 40 manats (1 manat = 0.59 U.S. dollars) per hectare for any crop they raised (van Berkum, 2017). Additionally, in 2017 President Ilham Aliyev issued a proclamation promoting the production of cotton, tobacco, and sugar beets. The government paid on a per kilogram basis, 0.1 manat for cotton and 0.05 manat for tobacco. It paid 4 manat per ton for sugar beets. This amounted to annual payments of about 190 manats for cotton, 125 manats for tobacco, and 196 manats for sugar beets per hectare for average yields (van Berkum, 2017). According to provisions in the same proclamation, the government provided a discount of 50 manats per hectare on irrigation waters, seeds, fuel, and fertilizers for any crop. They also offered preferential terms on farm machinery through “Agroleasing,” a state-owned company. An additional government order laid out plans to start a Credit Guarantee Fund, and investments were made to improve the irrigation system to provide irrigation water (van Berkum, 2017).

2.13. Azerbaijan’s Trade Policy

Trade with Russia and other countries in the Commonwealth of Independent States started in the late 1980s and early 1990s and, today, Turkey, Iran, and the Western European countries are important trading partners. Azerbaijan has good relations with regional trading partners such as Turkey, Georgia, Russia, and many of the central Asian countries and conducts a large agricultural import and export trade with them (Hague, personal communication, 9 July 2019). Azerbaijan’s major exports are petroleum and petroleum products, petrochemicals, oil field equipment, textiles, and cotton, while imports consist of machinery, consumer goods, foodstuffs, and textiles (van Berkum, 2017).

In 2019, Azerbaijan exported $123M worth of raw cotton, making it the 15th largest exporter of raw cotton in the world. It was also the 8th most exported product for Azerbaijan in 2019 (Raw Cotton in Azerbaijan, n.d.). The main destinations for Azerbaijan’s raw cotton are Turkey, Iran, Vietnam, Switzerland, and Bangladesh. The fastest growing export markets were Turkey, Iran, and Vietnam. In 2019, Azerbaijan imported $6.42k in raw cotton and became the 147th largest importer of raw cotton in the world. Azerbaijan imports most of its raw cotton from China and Turkey (Raw Cotton in Azerbaijan, n.d.).

Azerbaijan first applied to become a member of the World Trade Organization (WTO) in 1997 (van Berkum, 2017). The WTO promotes free trade by organizing trade negotiations and acts as an independent arbiter in settling trade disputes and is gaining success in promoting free trade. Following more than 24 years of trying, Azerbaijan has been unsuccessful in seeking membership in the WTO and has been unable to take advantage of the organization's trading relationships (van Berkum, 2017).

Benefits of free trade are: 1) countries can specialize in goods in which they have a comparative advance (less start-up costs); 2) trade barriers are reduced which creates trade; 3) exports increase; 4) economies of scale and lower average costs benefit from specialization; 5) desire for efficiency will encourage increased competition; trade promotes economic incentive (van Berkum, 2017).

To be accepted for membership in the WTO, it will be necessary for Azerbaijan to make changes in its farming structure to meet the demands of the modern marketplace. In many countries, it will be necessary to require farmers to give up outdated farming methods, learn modern technology, and the governments must increase economic development and train agronomic specialists who can educate farmers in efficient agricultural practices (van Berkum, 2017). They should support initiatives for farmers to seek better ways of farming, produce a better product, improve the handling of crops after harvest, and conform to international standards of quality (van Berkum, 2017).

2.14. Rural Welfare for Small-Scale Farmers

While the government has implemented policies affecting payments, subsidies, tax exemptions, and discounted machinery and supplies, it is nearly impossible for small-scale farmers to take advantage of the programs because “they simply cannot afford the investment in these inputs. There are 900,000 smaller farms with two hectares or less, and they are so small that their production is largely for the farmer’s own use, and only small surplus quantities are marketed.” (van Berkum, 2017) While some small farmers have possibly benefited from them, the government policies, such as special payment terms for equipment, fuel, and credit guarantees, cannot help because most of the farmers have low incomes, affordable credit is unavailable, and the machinery is not suited for working small parcels of land. Under the Soviet-era collective farm system, private initiative was discouraged because of socialist ideology (van Berkum, 2017).

Azerbaijan’s agricultural vocational school system is being improved to educate students in agricultural science. The government’s intended purpose is to train agronomic specialists to answer questions and guide farmers (van Berkum, 2017). This education is vital for dispersing technologies to farmers, but presently only 3.4 percent of agricultural workers have completed vocational education, and even fewer have an educational background in farm management (van Berkum, 2017). This low level of education for farmers, as well as unskilled labor, is slowly being addressed, but most Azerbaijanis continue to farm using traditional methods since they have little knowledge about how to use up-to-date technologies and research information (van Berkum, 2017).

Rural welfare has little chance for improvement unless farmers learn to use the latest scientific data in growing crops. Additionally, since people with little agricultural background and no farming experience received agricultural land during the government's land privatization distribution, agricultural education is greatly needed to educate them (van Berkum, 2017). Private land ownership has raised new concerns relating to the new farmers' inability to properly operate their family farms while also focusing on the lack of trained specialists in Azerbaijan who could advise them on farm management practices (Khalilov, 2019).

2.15. Land Privatization and Distribution

Before the Soviet Union's collapse, there was no private land in Azerbaijan because all agriculture production was carried out on state-owned collective farms. During the "post-Soviet transition" in 1991, those collective and state farms were transitioned into small, individually owned enterprises. The Azerbaijan government, with the support of IFAD, began the Farm Privatization Project that pioneered and oversaw the redistribution of land to farm members and rural citizens free of charge or for a small payment (Azerbaijan Works Towards Consolidating Fragmented Land, 2019). The government also passed privatization laws for land, as it established a market-based economy and gave 1.3 million hectares of cultivated land to 790,000 holders. After receiving the newly acquired land, rural households used it to produce their own food. The average rural household often consists of an extended family living in one dwelling or compound, shared by parents and their married sons, as well as the sons' families. Therefore, the act improved living conditions by relieving many rural people of food insecurity (Emirdirek, n.d.).

As a result of the Land Reform Act in 1996, the Azerbaijan government initiated an impressive program of agrarian reforms. This brought about a giant shift from the outdated Soviet-style, government-owned, collective farms to privately-owned individual farms, causing a remarkable turnaround that resulted in improved agricultural productivity and increased crop yields. The foundation for the land reforms began in the late 1980s as Soviet President Mikhail Gorbachev introduced *perestroika* (restructuring) while advocating for reforming the political system and bringing an end to central planning in government (Impact of Post-Soviet Transition) (Ibrahimov, 2016). There was speculation that Gorbachev was propagandizing perestroika to deceive soviet enemies into thinking that communism might be coming to an end. Nevertheless, Communism remained, but the Soviet Union had collapsed within five years (Ibrahimov, 2016).

Azerbaijan, along with the other Soviet republics, gained their independence in 1991 and some began reform policies. Russia, Ukraine, Kazakhstan, and other post-Soviet states also enacted land reform, but their policies still revolved around large corporate farms that slowed agricultural recovery. Because of its progressive plan, Azerbaijan has received international praise for being one of the few examples of successful land reform in the entire former Soviet Union (Ibrahimov, 2016; Qamar, 2013; Khalilov, 2019).

2.16. Agricultural Holdings

There were 1.2 million registered agricultural producers in Azerbaijan in 2015 (van Berkum, 2017). Altogether, Azerbaijan’s 900,000 small farms use fewer than 2.2

million hectares of farmland. Agricultural producers fall into one of three classifications: family farms and households, which by far comprise the largest group; agricultural enterprises; and private owners and entrepreneurs (van Berkum, 2017). Family farms average 2 hectares with households using 0.5 hectares or less for plots that produce mostly for home use. There are about 250,000 large-scale farms with more than 2 hectares of land (van Berkum, 2017).

2.17. Irrigation in Azerbaijan

Azerbaijan is heavily reliant on irrigation if it is to be successful with production agriculture. Irrigation and drainage networks that were constructed by the Soviet Union in the twentieth century were once used, operated, and maintained by brigades of the *sovkhoz and kolkhoz* (workers from collective socialist farms) (Stuart, 1974). After Azerbaijan land reform took effect, the irrigation canals fell into disrepair. The original earth canals have been modernized and replaced with a concrete-lined canal system. Hydraulic lift systems that carry water to about 760,000 users and members of Water User Associations (WUA) were also installed (Aliyeva and Ismayilov, 2019). Thirty-nine WUA-managed irrigation and drainage canal networks were rehabilitated by improving the irrigation infrastructure so that about 1,350,000 hectares are now irrigated in Azerbaijan. The area with irrigation and drainage services had increased from 53,000 hectares in 2011 to 920,274 hectares in 2012 (Khalilov, 2019). Despite these improvements, there is still substantial investment needed in Azerbaijan's irrigation networks.

Need for water is growing and to meet this demand, 135 reservoirs were built which regulate the irrigation system, and irrigation canals were built to irrigate hundreds of thousands of agricultural fields. The largest principal canals were built in the 1900s to provide irrigation water to lowlands areas. River systems, such as the Kura, the Samur, and the Aras are the main water sources for irrigation canals (Aliyeva and Ismayilov, 2019).

The World Bank supported a fundamental change in the way Azerbaijan manages irrigation systems and found a way that distributes irrigation water more efficiently (Khalilov, 2019). The Bank, along with the International Fund for Agricultural Development (IFAD), and others had a plan to put the management of distribution canals under the control of water user associations while leaving the main canal to be managed by the Amelioration Irrigation Open Joint Stock Company (AIOJSC) (Khalilov, 2019). The WUAs receive water in bulk delivery from the AIOJSC and distribute irrigation water to their members. The World Bank pioneered, established, and supported the Water Associations Development Project (WUAP). It provided U.S. $80 million over a period of 25 years to fund a change in the development of irrigation and drainage as Azerbaijan converted from state-owned management to a system of being run by water user association system (Khalilov, 2019). The World Bank also provided technical training to help farmers manage and operate the systems. The project not only supported water user associations, but also demonstrated "the practicability of participatory irrigation management." (Azerbaijan, n.d.; Khalilov, 2019)

The project benefited about 760,000 WUA members by the time it ended in 2018, and had achieved impressive results:

- Farmers reported an increase in their yields by more than 20 percent.
- Agricultural productivity increased 15 percent or higher on 71,681 hectares of irrigated land compared to 2011.
- Ninety-two percent of rehabilitated systems received more than 80 percent of the irrigation water they had requested compared to 20 percent in 2011.
- Seventy-three percent of surveyed farmers expressed satisfaction with WUA managerial and operational performance in 2018 compared to 20 percent in 2011 (Khalilov, 2019).

2.18. Azerbaijan Culture

Azerbaijan is divided between rural areas that are traditional and underdeveloped and the large, cosmopolitan city of Baku, which is Azerbaijan's capital (Emirdirek, n.d.). Baku is comparable to any of the capitals of Europe in terms of technology, cultural sites, and businesses. The most striking contrast can be seen in the way the people in each sector live. Since the Azerbaijanis who live in Baku have higher incomes, their homes are much larger and are decorated with Persian-influenced furnishings, such as carpets, chandeliers, and beautifully decorated gates at the entrances of their compounds (Emirdirek, n.d). They drive Range Rovers and Mercedes. They can attend concerts, theater performances, the ballet, and enjoy fine dining, the arts, and educational advantages. Their urban, fast-paced lifestyles are a sharp contrast to the quiet, slow-paced, country-style lives of rural residents (Emirdirek, n.d.).

On the other hand, most rural Azerbaijanis are farmers and earn a living in agriculture. Their incomes are among the lowest in their country (van Berkum, 2017). They live in small, simple dwellings that often provide living quarters for multiple families. Their diets consist of fruits and vegetables grown in small plots or gardens maintained by family members. Women and older children often work on large farms where they hoe weeds and harvest cotton and fruit by hand (Emirdirek, n.d.). Rural residents own cars, but they are usually older, Russian-built vehicles, such as Ladas.

Figure 2.1 Small Russian-built vehicles, such as the Lada, are driven by many Azerbaijanis.

2.19. Value of Small Variety Test Plots

There is value in testing cotton varieties in small plots rather than trying new varieties on large sections of a farm. This reduces the risk of planting varieties without a history of performance. Testing many varieties within one field allows for easier observations and allows for replication within the field (Leep and Meints, 1984).

Specific aims for variety trial plots are to:

- evaluate varieties for earliness of maturity.
- estimate yield potential.
- determine resistance to pests .
- measure fiber quality under similar growing conditions (Leep and Meints, 1984).

The knowledge gained in observing for early maturity of varieties allows farmers to plant these varieties. The benefits of the early maturing varieties allow the crop to take advantage of summer heat units and mature earlier which allows for an expedited harvest to avoid unexpected fall rains (Leep and Meints, 1984).

2.20. Cotton Defoliation

The process of defoliation can be described as the shedding of cotton leaves that naturally occurs when leaves become physiologically mature (Barber, 2013). It is a common practice to artificially defoliate cotton with harvest aids or defoliants. It is critical to remove vegetation prior to harvest so that mechanical harvesters can harvest the crop efficiently with minimal vegetative material and moisture contaminating the seed cotton. Harvesting cotton that has a high leaf retention causes staining of fibers, elevates moisture content, and damages lint grade (Barber, 2013).

Defoliation treatments are usually split into two applications. The first application usually occurs when the crop reaches 60% open bolls. The second application is made 7 to 10 days after the initial treatment. Environmental factors, such as temperature and rainfall, can negatively affect the efficacy of the treatment. (Barber, 2013). Depending upon conditions, rates should be modified so there is minimal leaf desiccation, which causes leaves to stick to the plant and increases trash content in the harvested crop (Barber, 2013).

Harvest aids can be split into two groups--herbicidal-type and hormonal defoliants. Herbicidal- type defoliants cause injury to the crop which induces the crop to produce ethylene and encourages leaf drop. Hormonal defoliants applied to a crop cause the plant to increase ethylene synthesis. This process results in the abscission of leaf petioles and is not as likely to cause leaves to stick on the plant. The first application is used to remove foliage, and the second application sometimes includes a boll-opening agent to open bolls that have not fully matured (Barber, 2013; Stewart, 2012). The second application often inhibits regrowth and is better able to reach leaves in the lower portion of the original canopy.

2.21. Fertilizer and Nutrient Requirements

Nitrogen is an important and costly input in cotton production. The plant needs additional nitrogen during fruiting and in the formation of bolls. An excessive application of nitrogen can cause cotton to have unnecessary vegetative growth, attract insect pests, and can have a negative impact on ground and surface water. If too little is applied, there can be a loss of yield and fiber quality can be compromised. Soil testing can be used to identify the nutrient status of the soil prior to planting so that inputs can be made to meet the nutrient requirements of the crop (Hons et al., 2015; Soil Fertility, n.d.). A typical soil analysis will account for the nutrient status of the field sampled. This process is beneficial to the farmer because nitrogen is a highly mobile nutrient that can be leached from the soil. Nitrogen applications should be adjusted based on soil type (Soil Fertility, n.d.).

Potassium is a nutrient that is not easily leached from the soil. Cotton requires the highest amount of potassium when there are developing bolls on the plant. The bolls utilize high amounts of potassium so that they can maintain water pressure while the fibers are being developed (Soil Fertility, n.d.).

Phosphorus is almost immobile in soil; thus, root systems should be well developed in order to uptake a sufficient amount of phosphorus. The cotton crop will uptake the highest amount during peak fruiting, and if it is unavailable to the plant, phosphorus deficiency can lead to a reduction in yield (Soil Fertility, n.d.).

There are three secondary nutrients that can have an effect on the crop--calcium, magnesium, and sulfur. Calcium is needed in high amounts because it strengthens cell walls and promotes cell division and plant growth (Soil Fertility, n.d.).

Comprehensive soil fertility programs should be implemented and soil types, yield goals, cost of soil amendments, cropping history, and climate should be considered. Soil fertility programs also should rely upon soil analyses from frequent samples within the field. This allows for proper soil management and reduces inefficient applications (Soil Fertility, n.d.).

3. MATERIALS AND METHODS

3.1. Cotton Variety Trials

All cotton trials were conducted at two MKT-owned farms in Imishli and Goran Azerbaijan. MKT LLC has its headquarters in Baku and is the “Cotton brand name of Azerbaijan” (MKT Cotton LLC, n.d.), the company works to acquire land and incorporate those hectares into cotton production. In 2018, ten cotton varieties were planted in Imishli, and nine varieties were planted in Goran. In 2019, eight cotton varieties were planted in both Imishli and Goran (Table 3.1). Cotton planting usually occurs in mid to late April in both locations. All locations utilized overhead pivot irrigation systems. The crop was maintained by MKT employees for weed control by hand.

Table 3.1 Cotton varieties included in the cotton variety trials in Azerbaijan.

Varieties Planted in Azerbaijan			
2018		2019	
Imishli	Goran	Imishli	Goran
May 505	May 505	May 505	May 505
ProGen Lima	ProGen Lima	ProGen Lima	ProGen Lima
Beyaz Altin 440	Beyaz Altin 440	Beyaz Altin 440	Beyaz Altin 440
May 455	May 455	May 455	May 455
May 344	May 344	May 344	May 344
ProGen Flash	ProGen Flash	ProGen Flash	ProGen Flash
Golden West	Golden West	Golden West	Golden West
Esperia	Esperia	Esperia	Esperia
Golden West 2345	Golden West 2345		
ProGen 2018	ProGen 2018		
Golden West Bomba			

In 2018, varieties were planted in one-row plots that ran the length of the field. The planting rate was approximately 18 seeds per linear meter row. Planting in both locations was conducted on row spacing of 0.9144 meters. The experiment was in a randomized complete block design with three replications. Throughout the plot, there were sections that contained missing plants. To have a representative sample of the plot, a ten-meter section was sampled, this section was selected and contained the least amount of missing plants.

At harvest, a ten-meter section, which was representative of the plot, was hand harvested. This approach created a more homogeneous trial and allowed us to have more control over variation than if we had used mechanical harvesters for the entire row. Since each row was a different length, and some rows had center pivot tire tracks running through them, there was variation throughout the experiment in varying degrees. Plots were harvested when plants had more than 90% open bolls. Seed cotton samples were ginned on a small-scale roller gin at the gin near Imishli.

The entire harvested sample was ginned for each plot and a sub-sample of approximately 40 grams of fiber was taken to measure the fiber. Fiber samples were sent to the Texas Tech Fiber and Biopolymer Research Institute in Lubbock, Texas. Each fiber sample was measured using High Volume Instrument Testing (HVI). The variables used in this experiment were:

- micronaire
- length
- uniformity

- strength
- elongation

Figure 3.1 Seed cotton samples were ginned on this small-scale roller gin at Imishli, Azerbaijan.

In 2019, eight varieties were planted in Goran and eight varieties were planted in Imishli. The experiment was conducted using a randomized complete block design with three replications. The plot length was ten meters in length and had approximately 18 seeds per meter. Two crop observation trips throughout the growing season were made to Azerbaijan: one in June around first bloom and the other in July, approximately 30 days later.

Since there were skips and weedy areas in the plot, the best five meters of the plot were selected, harvested by hand, and samples weighed. Approximately 200 grams of seed cotton were taken from each plot and ginned out on a small-scale roller gin at the gin near Imishli. A sub-sample of approximately 40 grams of ginned cotton was taken to measure the fiber. Fiber samples were sent to the Texas Tech Fiber and Biopolymer Research Institute in Lubbock, Texas. A fiber sample from each variety plot was measured using High Volume Instrument testing (HVI). All data was analyzed using SAS 9.4. Cotton variety data was analyzed using Proc GLM, differences were considered statistically significant at the .05 level unless otherwise specified. Yield and HVI fiber data was run across years and locations

3.2 Defoliation Trials

In 2019, fields were planted in Goran and Imishli using ‘GW Bomba’ as the variety. The defoliation trial was a randomized complete block design and spray applications were made to the plot rows that ran the length of the entire field. Each plot was eight rows wide, and all measurements were taken from the 2 center rows which reduced the potential effects of drift from adjacent treatments. Treatments of Baystar® (a defoliant, thidiazuron and diuron) and Son-Final® (a boll opener, ethephon and cyclanilide) were applied by MKT employees using commercial scale sprayers. Data, such as the percent of leaf drop, the ratio of open to green bolls, and percentage of stuck leaves remaining on the plant were measured. Trials in Goran were harvested by hand, and in Imishli plots were harvested using mechanical harvesters.

Table 3.2 Treatments in the defoliation trial at Goran, Azerbaijan, in 2019.

Treatment #	**11 September**		**22 September**	
	Baystar ($l\ ha^{-1}$)	**Son-Final ($l\ ha^{-1}$)**	**Baystar ($l\ ha^{-1}$)**	**Son-Final ($l\ ha^{-1}$)**
1	0.47	0.00	0.00	0.00
2	0.47	1.53	0.00	0.00
3	0.64	0.00	0.00	0.00
4	0.64	1.53	0.00	0.00
5	0.23	1.53	0.23	0.00
6	0.23	1.53	0.47	0.00
7	0.47	1.53	0.47	0.00

Table 3.3 Treatments in the defoliation trial at Imishli, Azerbaijan, in 2019

Treatment #	19 September		25 September	
	Baystar ($l\ ha^{-1}$)	Son-Final ($l\ ha^{-1}$)	Baystar ($l\ ha^{-1}$)	Son-Final ($l\ ha^{-1}$)
1	0.47	0.00	0.26	0.00
2	0.16	1.06	0.33	0.95
3	0.64	0.00	0.34	0.00
4	0.64	1.53	0.00	0.00
5	0.23	1.53	0.50	0.00
6	0.23	1.53	0.50	0.76
7	0.16	1.06	0.33	1.78

In 2020, a similar defoliation trial was conducted at College Station, Texas. The trial was a randomized complete block with four replications. Treatments of Ginstar® (a defoliant, thidiazuron and diuron) and Super Boll (a boll-opener, ethephon) were applied to a four-row plot with a boom sprayer. Each test plot ran the length of the field. Data was collected from the center rows, a section of approximately one meter was flagged and used for data collection of the percentage of open and green bolls. Plots were harvested using a mechanical harvester, and grab samples were taken from harvest bags of each plot.

Table 3.4 Treatments in the defoliation trial at College Station, Texas, in 2020.

Treatment #	**11 August**		**17 August**	
	Ginstar ($l\ ha^{-1}$)	**Super Boll ($l\ ha^{-1}$)**	**Ginstar ($l\ ha^{-1}$)**	**Super Boll ($l\ ha^{-1}$)**
1	0.47	0.00	0.26	0.00
2	0.16	1.06	0.33	0.95
3	0.64	0.00	0.34	0.00
4	0.64	1.53	0.00	0.00
5	0.23	1.53	0.50	0.00
6	0.23	1.53	0.50	0.76
7	0.16	1.06	0.33	1.78

Variable combination rates of defoliants and boll-openers were applied twice, the timing of the first application was done when the crop had approximately 60% open bolls, and the second application was made eleven days later at both Azerbaijan locations, and six days later in College Station, Texas. The common practice of two applications were applied with the objective of determining a rate of defoliant that minimizes the amount of foliage remaining on the crop at the time of harvest. Treatments were applied to plots, and after the labeled reentry interval for worker protection had passed, the team walked into the middle of the spray treatment rows. Rows 4-5 in 2019, and rows 2-3 in 2020, were used for observations and collections, in an area that best represented the plants in each test plot. Within that designated two-meter portion of the row, all green and open bolls were counted. The amount of leaves that had dropped from plants were estimated from a two-meter section representative of each test plot. All data was analyzed using SAS 9.4. Defoliation data was analyzed using Proc GLM, HVI and AFIS fiber data analyzed for each location for each year. HVI fiber data from Imishli and College Station was analyzed to see if there was any location by treatment interaction.

3.3. Nitrogen Fertilizer Trials

In 2019, on MKT Farms in Goran and Imishli, plots that were 10 meters in length were planted with the cotton variety of GW Bomba, at a seeding rate of approximately 15 seeds per meter. The experiment was conducted using a randomized complete block design with a four-row plot replicated three times. Two sources of nitrogen were used, granular ammonium nitrate and liquid monoammonium phosphate (Table 3.5). The liquid monoammonium phosphate was applied with the MKT mechanical knifing unit while the ammonium nitrate was applied by hand and incorporated the next day with tillage to minimize nitrogen losses due to potential volatilization.

Table 3.5 Nitrogen fertilizer rates for trials in Goran and Imishli, Azerbaijan.

Code	Fertilizer type	Product Rate	Nitrogen Rate
P100	Monoammonium phosphate (12-52-0)	100 kg Ha^{-1}	52 kg Ha^{-1}
P200	Monoammonium phosphate (12-52-0)	200 kg Ha^{-1}	104 kg Ha^{-1}
P300	Monoammonium phosphate (12-52-0)	300 kg Ha^{-1}	156 kg Ha^{-1}
0 N	None-control	0 kg Ha^{-1}	0 kg Ha^{-1}
50 N	Ammonium nitrate (33-0-0)	151 kg Ha^{-1}	50 kg Ha^{-1}
100 N	Ammonium nitrate (33-0-0)	303 kg Ha^{-1}	100 kg Ha^{-1}
150 N	Ammonium nitrate (33-0-0)	455 kg Ha^{-1}	150 kg Ha^{-1}
200 N	Ammonium nitrate (33-0-0)	606 kg Ha^{-1}	200 kg Ha^{-1}
250 N	Ammonium nitrate (33-0-0)	758 kg Ha^{-1}	250 kg Ha^{-1}

In 2020, at College Station, Texas, an almost identical nitrogen trial was conducted. Nitrogen test plots were 12.2 meters in length with four rows in each test plot. The experiment used a randomized complete block design with four replications. The variety planted for the entire test was ‘Tamcot 73’ (Smith et. al., 2011). Granular applications were made by hand at the time of first bloom stage and within two days incorporated with cultivation. Urea fertilizer was used for test plots in College Station, Texas.

Table 3.6 Nitrogen fertilizer rates for trials in College Station, Texas.

Code	Fertilizer type	Product Rate	Nitrogen Rate
0 N	None-control	0 kg Ha^{-1}	0 kg Ha^{-1}
50 N	Urea (46-0-0)	151 kg Ha^{-1}	50 kg Ha^{-1}
100 N	Urea (46-0-0)	303 kg Ha^{-1}	100 kg Ha^{-1}
150 N	Urea (46-0-0)	455 kg Ha^{-1}	150 kg Ha^{-1}
200 N	Urea (46-0-0)	606 kg Ha^{-1}	200 kg Ha^{-1}
250 N	Urea (46-0-0)	758 kg Ha^{-1}	250 kg Ha^{-1}

Fertilizer applications at the Azerbaijan and College Station locations were split, with half applied prior to planting and half applied at first bloom. Only the middle two rows of each plot were used for collecting data. Soil samples were not collected prior to planting in Azerbaijan or in College Station, Texas. Nitrogen trials conducted in College Station were irrigated using furrow irrigation, and the soil type of the field was ‘Ships clay’, with slopes less than one percent. Plots at Goran and Imishli were harvested by hand and grab samples for fiber measurements were taken. At College Station plots were mechanically harvested and grab samples for fiber measurements were taken.

All data were analyzed using SAS 9.4. Nitrogen data were analyzed using Proc GLM, differences were considered statistically significant at the .05 level. Yield and HVI fiber data was run across years and locations

4. RESULTS

4.1. Cotton Variety Trials

Variety trials were conducted in 2018 and 2019 in Goran and Imishli, Azerbaijan. Varieties that were not included in every trial were excluded. Variety trials were then analyzed across years and locations and significance was looked for at the 0.05 probability level. The data was analyzed using SAS 9.4 analytics software, for agronomic yield measurements and fiber data that was obtained from HVI measurements.

Table 4.1 Analysis of variance of yield characteristics from the combined cotton variety trials in Azerbaijan in 2018 and 2019 (* significant at the .05 probability level).

Source	df	Seedcotton		Lint	
		MS	F	MS	F
Year	1	64,144,934	21.82*	8,915,096	19.06*
Rep(Year)	4	1,723,310	3.22*	290,098	3.04*
Location	1	16,461,047	14.82	3,143,094	16.22*
Cultivar	6	419,247	0.26	138,603	0.41
Cultivar*Year	6	1,317,935	3.38	230,264	5.41*
Location*Year	1	833,537	2.13	87,327	2.04
Cultivar*Location	6	668,602	1.71	149,656	3.51
Cultivar*Location*Year	6	389,986	0.73	42,597	0.45
Error	50	1,110,492		337,323	

Lint yields from the variety trials were among the only factors to show significance. There were significant differences among cultivars across years. Then trials were then analyzed separately, and the means tables are shown.

Table 4.2 Analysis of variance of fiber traits as measured by HVI for combined variety trials in Azerbaijan, in 2018 and 2019 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength	
		MS	F	MS	F	MS	F	MS	F
Year	1	0.52	2.09	4.12	4.12	0.98	0.4	1153.84	4.88
Rep(Year)	4	0.02	0.18	0.43	0.53	1.20	1.12	196.64	0.81
Location	1	15.86	52.53	55.56	22.91	9.52	9.52	12.20	0.02
Cultivar	6	0.17	1.55	4.69	9.33	1.24	1.24	1266.63	4.31
Cultivar*Year	6	0.09	1.66	0.21	0.27	0.85	0.85	124.07	0.42
Location*Year	1	0.28	4.84	2.15	2.69	2.29	2.29	439.45	1.50
Cultivar*Loc	6	0.07	1.32	1.08	1.36	1.24	1.24	465.92	1.57
Cult*Loc*Year	6	0.05	0.61	0.8	0.98	0.78	0.78	295.87	1.21
Error	45	0.09		0.82		1.07		243.77	

Table 4.3 Cotton fiber quality as measured by HVI for combined variety trials in Azerbaijan, in 2018 and 2019.

Variety	Micronaire	Length	Uniformity	Strength
	unit	mm	%	kNm/kg
BA 440	5.0	28.7	84.4	313
Esperia	4.8	29.1	84.7	308
May 344	4.7	29.7	85.0	290
May 455	4.8	29.5	85.3	322
May 505	5.0	29.6	85.4	311
PG Flash	4.8	30.7	85.4	305
PG Lima	4.9	30.5	85.3	319
Mean	4.8	29.7	85.1	310
LSD (0.05)	N.S.	N.S.	N.S.	N.S.
C.V.,%	11.5	4.8	1.3	6.0

There were no differences among the cotton varieties fiber quality measured by HVI. Variety trials in Goran and Imishli were inspected two times during the growing season- the first inspection occurred in June and the second took place in July. In June, plots were inspected, and it was noted that plots within the test were weedy . To have a successful variety trial, weed control is essential throughout the plots. Early control of weed populations should take priority to limit competition for resources. Maximum competition occurs approximately eight weeks after the emergence of cotton plants (Ferrell et al., n.d.). Late season weeds compete for resources, cause problems during mechanical harvesting, and limit the amount of herbicide applied to the cotton plant (Ferrell et al., n.d.). Weed prevention used throughout the season helps to reduce plants that can mature and add thousands of seeds to the soil that have the potential to persist for decades (Colquhoun, 2003).

Table 4.4 Analysis of variance of yield characteristics from the cotton variety trial in Goran, Azerbaijan in 2018 (* significant at the .05 probability level).

Source	df	Seedcotton		Lint	
		MS	F	MS	F
Rep	2	1,696,227	2.99	296,371	3.28
Cultivar	6	1,121,042	1.98	243,220	2.69
Error	10	566,467		90,330	

Table 4.5 Yield characteristics of the variety trial in Goran, Azerbaijan in 2018.

Variety	Seed cotton	Lint
	kg ha^{-1}	kg ha^{-1}
May 505	5,943	2,421
PG Lima	5,489	2,334
BA 440	5,249	2,131
May 455	5,099	2,039
May 344	4,757	1,957
Esperia	4,426	1,805
PG Flash	4,225	1,622
Mean	5,029	2,044
LSD (0.05)	N.S.	N.S.
C.V.,%	15.0	14.7

Lint yields from the cotton variety trials at Goran averaged 2044 kg ha^{-1} (Table 4.5). Lint yields of most of the varieties showed little difference from the highest ranked variety, 'May 505'. Good management practices throughout the season led to a well grown crop in Goran. We suspect that yields could possibly be increased if planting density is lowered. Lowering the planting density helps to increase retention of bolls throughout the plants and provides an economic benefit (Khan et al., 2019).

Table 4.6 Analysis of variance of yield characteristics from the cotton variety trial in Imishli, Azerbaijan in 2018 (* significant at the .05 probability level).

Source	df	Seedcotton		Lint	
		MS	F	MS	F
Rep	2	26,894	0.09	2,804	0.07
Cultivar	6	620,716	2.13	78,637	0.15
Error	12	291,736		40,147	

Table 4.7 Yield characteristics of the variety trial in Imishli, Azerbaijan 2018.

Variety	Seed cotton	Lint
	kg ha^{-1}	kg ha^{-1}
May 505	4,747	1,920
PG Flash	5,054	1,887
May 455	4,310	1,759
PG Lima	4,127	1,661
May 344	4,039	1,630
Esperia	3,944	1,555
BA 440	3,801	1,493
Mean	4,289	1,701
LSD (0.05)	N.S.	N.S.
C.V.,%	12.6	11.8

Lint yields at Imishli were slightly lower than lint yields harvested at Goran (Table 4.7). Imishli's average lint yield was 1701 kg ha^{-1} which was more than 340 kg less than Goran. The yield differences were likely a consequence of the salt stress at Imishli. Rankings among varieties changed little between locations. May 505 topped both trials and Esperia ranked at or near the bottom at both locations. PG Flash was the only variety that changed substantially in yield performance. PG Flash appeared to be better suited to Imishli than to Goran. This likely indicates a higher presence of salt tolerance.

Table 4.8 Analysis of variance of yield characteristics from the cotton variety trial in Goran, Azerbaijan in 2019 (* significant at the .05 probability level).

Source	df	Seedcotton		Lint	
		MS	F	MS	F
Rep	2	3,966,620	4.67*	726,060	4.52*
Cultivar	6	871,045	1.02	196,595	1.22
Error	12	850,112		160,511	

Table 4.9 Yield characteristics of the variety trial in Goran, Azerbaijan in 2019.

Variety	Seed cotton	Lint
	kg ha^{-1}	kg ha^{-1}
PG Lima	4,009	1,766
Esperia	4,031	1,679
BA 440	3,793	1,596
May 344	3,259	1,379
May 455	3,200	1,330
May 505	2,756	1,158
PG Flash	2,813	1,107
Mean	3,409	1,431
LSD (0.05)	N.S.	N.S.
C.V.,%	27.1	28.0

At Goran, the two lowest-yielding varieties were 'May 505' and 'PG Flash' (Table 4.9). Interestingly, they were also the two lowest-yielding varieties in Imishli (Table 4.11). During the two observational visits to Goran, it was noted that the research trials were well managed. Weed pressure was minimal and plots appeared to have been irrigated at the correct time. Minimal variation among varieties for yield may be a cause of varieties sourced from similar breeding programs.

Table 4.10 Analysis of variance of yield characteristics from the cotton variety trial in Imishli, Azerbaijan in 2019 (* significant at the .05 probability level).

Source	df	Seedcotton		Lint	
		MS	F	MS	F
Rep	2	501,004	3.19	135,156	5.42*
Cultivar	6	232,545	1.48	52,397	2.10
Error	12	157,049		24,947	

Table 4.11 Yield characteristics of the variety trial in Imishli, Azerbaijan in 2019.

Variety	Seed cotton	Lint
	kg ha^{-1}	kg ha^{-1}
Esperia	2,597	1,148
May 455	2,575	1,094
PG Lima	2,577	1,068
BA 440	2,252	930
May 344	2,133	895
May 505	2,009	832
PG Flash	1,969	822
Mean	2,302	970
LSD (0.05)	N.S.	N.S.
C.V.,%	17.2	16.3

In 2019, lint yields at Imishli were again slightly lower than yields harvested at Goran (Table 4.11). Yields averaged 450 kg less than trials in Goran. Yield and fiber data could have been affected by many factors associated with improper management. It was observed that many of the overhead irrigation sprinklers on the pivot systems were high above the canopy of the crop. Irrigating with high saline water, while not optimal, can be done. Reducing the amount of evaporation that happens is crucial to reduce salt presence. It is recommended that irrigation sprinklers should be placed lower to the canopy of the crop to allow water to leach salt beyond the rooting zone. Salinity stress negatively affects cotton in many ways such as reduced boll development, decreased root formation, and also causes an impact on germination rates (Sharif et al., 2019).

4.2. Defoliation Trials

Trials conducted at Imishli and Goran, Azerbaijan, were carried out to determine which treatment rates aided in the highest rates of defoliation. Data obtained from yield measurements, HVI, and AFIS measurements were analyzed using SAS 9.4. Significance was determined at the 0.05 probability level.

Table 4.12 Treatments in the defoliation trial at Goran, Azerbaijan, in 2019.

Treatment	11-Sep		22-Sep	
	Baystar ($l\ ha^{-1}$)	Son-Final ($l\ ha^{-1}$)	Baystar ($l\ ha^{-1}$)	Son-Final ($l\ ha^{-1}$)
1	0.47	0	0	0
2	0.47	1.53	0	0
3	0.64	0	0	0
4	0.64	1.53	0	0
5	0.23	1.53	0.23	0
6	0.23	1.53	0.47	0
7	0.47	1.53	0.47	0

Table 4.13 Analysis of variance of fiber traits as measured by HVI from the defoliation trial at Goran, Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Rep	2	0.07	0.52	4.82	3.33	0.22	0.28	538.41	1.29	0.04	0.41
Treatment	6	0.05	0.38	0.99	0.68	0.94	1.17	53.43	0.13	0.08	0.57
Error	12	0.14		1.45		0.80		418.69		0.10	

Table 4.14 Cotton fiber quality as measured by HVI from the defoliation trial at Goran, Azerbaijan, in 2019.

Treatment	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
1) B(0.47)+S(0.00) & B(0.00)+S(0.00)	4.6	29.3	85.3	321	7.7
2) B(0.47)+S(1.53) & B(0.00)+S(0.00)	4.5	30.0	86.2	313	7.5
3) B(0.64)+S(0.00) & B(0.00)+S(0.00)	4.7	29.2	85.0	317	7.8
4) B(0.64)+S(1.53) & B(0.00)+S(0.00)	4.7	30.4	85.3	317	7.4
5) B(0.23)+S(1.53) & B(0.23)+S(0.00)	4.9	29.7	84.3	319	7.4
6) B(0.23)+S(1.53) & B(0.47)+S(0.00)	4.6	29.9	85.4	314	7.5
7) B(0.47)+S(1.53) & B(0.47)+S(0.00)	4.5	30.8	85.2	308	7.4
Mean	4.6	29.9	85.3	316	7.5
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	8.1	4.0	1.1	6.5	4.2

There were no significant differences among the defoliation treatments for fiber quality as measured by HVI. Fiber traits from samples collected from the defoliation trial at Goran showed no differences among treatments suggesting that defoliation rates and timing of application had no effect on these HVI parameters (Table 4.14). The least expensive rate of defoliant and boll opener had similar effects compared to the highest rates, which should be considered when producers attempt to minimize input costs.

Table 4.15 Fiber color and trash as measured by HVI from the defoliation trial at Goran, Azerbaijan, in 2019.

Treatment	Reflectance (Rd)	Yellowness (+b)	Leaf Grade
1) B(0.47)+S(0.00) & B(0.00)+S(0.00)	78.0	8.0	3.0
2) B(0.47)+S(1.53) & B(0.00)+S(0.00)	79.5	8.2	1.3
3) B(0.64)+S(0.00) & B(0.00)+S(0.00)	78.6	8.1	1.7
4) B(0.64)+S(1.53) & B(0.00)+S(0.00)	78.3	8.2	2.0
5) B(0.23)+S(1.53) & B(0.23)+S(0.00)	78.9	8.2	2.7
6) B(0.23)+S(1.53) & B(0.47)+S(0.00)	77.7	8.2	4.0
7) B(0.47)+S(1.53) & B(0.47)+S(0.00)	77.9	8.1	4.0
Mean	78.4	8.2	2.7

Samples were hand-harvested in Goran and may have contributed to higher reflectance and cleaner leaf grades compared to Imishli where samples were collected from inside the cotton harvester (Table 4.15 and 4.21). The yellowness measurements from all treatments suggest that they were fully mature and were not negatively impacted by rainfall. Treatments #6 and #7 included a second application of Baystar, which likely resulted in more desiccated leaves and a higher leaf grade on those treatments at the time of harvest. Minimizing leaf trash and producing fibers graded as ‘white’ are important goals when applying defoliation applications.

Table 4.16 Analysis of variance of fiber traits as measured by AFIS from the defoliation trial at Goran, Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Neps/g		UQL		SFC (n)		Fineness		IFC		Maturity	
		MS	F	MS	F	MS	F	MS	F	MS	F	MS	F
Rep	2	148.00	0.85	1.07	1.52	2.06	0.17	115.61	0.81	1.09	0.74	0.0007	0.42
Treatment	6	276.31	1.58	1.02	1.45	9.75	0.82	63.30	0.44	0.42	0.29	0.0004	0.25
Error	12	174.88		0.71		11.91		143.56		1.48		0.002	

Table 4.17 Cotton fiber quality as measured by AFIS from the defoliation trial at Goran, Azerbaijan, in 2019.

Treatment	Nep/g	UQL	SFC (n)	Fineness	IFC	Maturity
	unit	mm	%	m/tex	%	ratio
1) B(0.47)+S(0.00) & B(0.00)+S(0.00)	52.3	30.7	24.1	180	5.8	0.92
2) B(0.47)+S(1.53) & B(0.00)+S(0.00)	50.3	31.2	22.4	175	6.8	0.89
3) B(0.64)+S(0.00) & B(0.00)+S(0.00)	56.0	31.1	23.9	173	6.6	0.89
4) B(0.64)+S(1.53) & B(0.00)+S(0.00)	55.0	31.8	20.8	172	6.3	0.90
5) B(0.23)+S(1.53) & B(0.23)+S(0.00)	36.0	30.0	19.5	180	5.8	0.92
6) B(0.23)+S(1.53) & B(0.47)+S(0.00)	42.7	31.1	21.4	176	6.4	0.90
7) B(0.47)+S(1.53) & B(0.47)+S(0.00)	65.7	30.6	20.1	167	6.2	0.91
Mean	51.1	30.9	21.8	175	6.2	0.90
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	25.9	2.7	15.9	6.9	19.5	4.5

There were no differences among the defoliation treatments for fiber quality as measured by AFIS. The lightest application of fertilizer applied had similar results to the heaviest application. There is no economic advantage to applying heavy rates nitrogen.

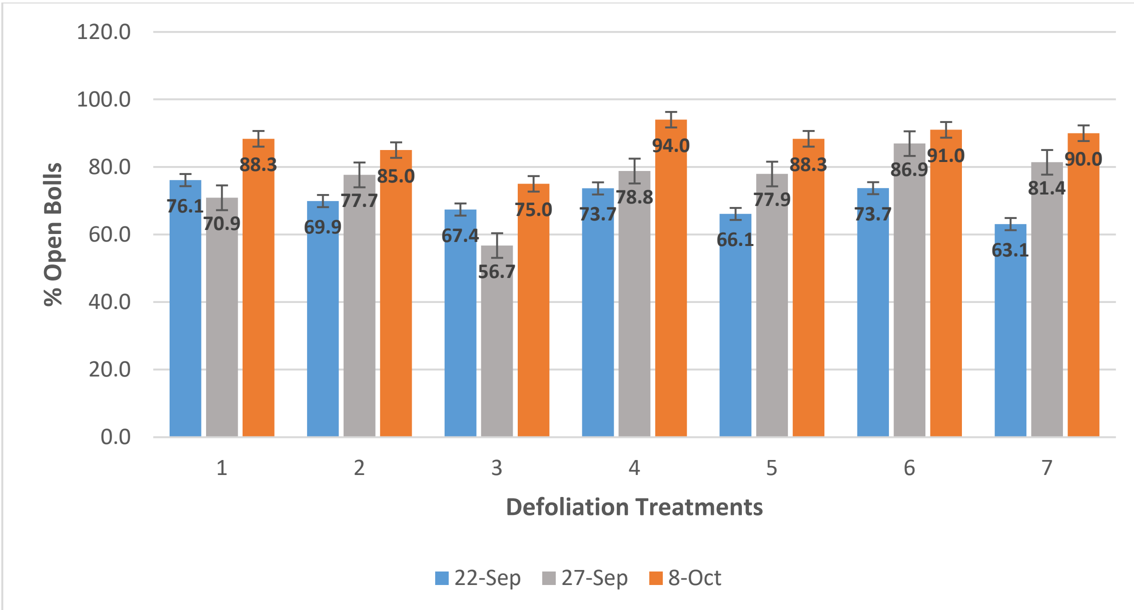

Figure 2. Percent open boll averages of replicate treatment plots at Goran, Azerbaijan, 2019.

At Goran, treatments that reached above 85% open bolls were considered desirable (Figure 3). Treatments that contained lower initial rates of Baystar with Son Final along with second applications of Baystar showed improved boll opening percentages. Treatments that contained lower initial rates, or did not contain a second application, showed lower rates of open bolls compared to treatments that utilized split applications or higher initial rates.

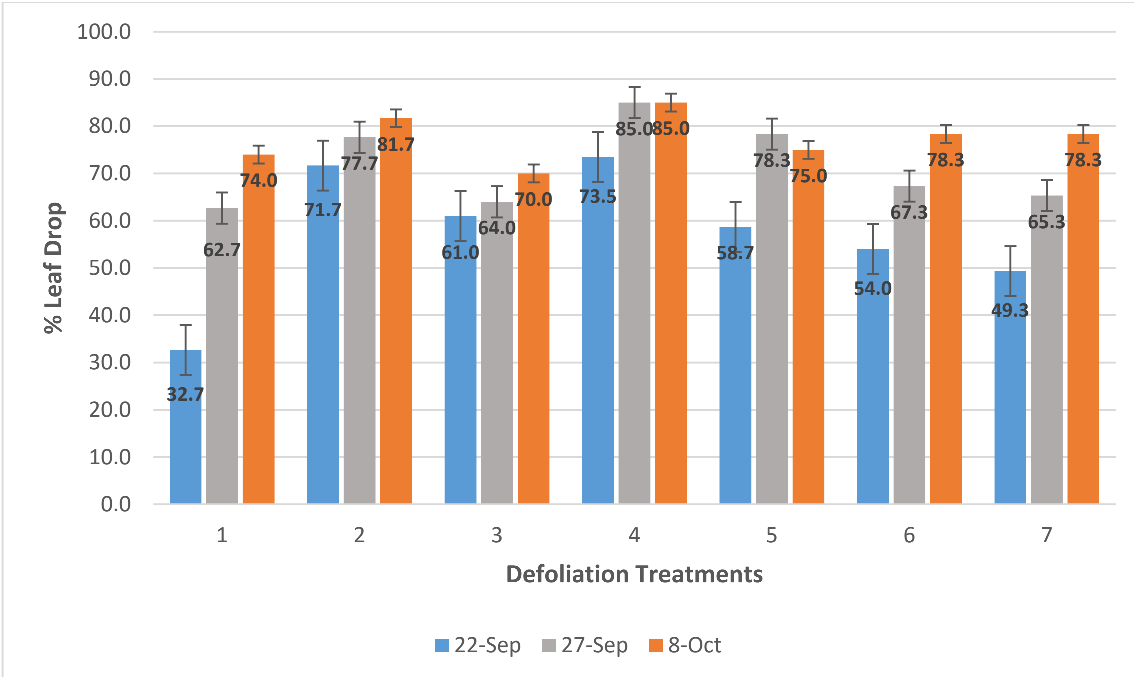

Figure 3. Percent leaf drop averages of replicate treatment plots at Goran, Azerbaijan, 2019.

Treatment #4 achieved the highest rate of defoliation (Figure 4). This treatment contained the highest rate of Baystar (0.64 liters per hectare) and Son Final (1.53 liters per hectare) (Table 4.12).Treatments that contained a high initial application of Baystar and Son Final provided high rates of defoliation. Lower initial rates of Baystar and Son Final, combined with Baystar in the second application, did show improvement later by increasing leaf drop percentages (Figure 4).

Table 4.18 Treatments in the defoliation trial at Imishli, Azerbaijan, in 2019.

Treatment	19-Sep		25-Sep	
	Baystar	Son-Final	Baystar	Son-Final
	($l\ ha^{-1}$)	($l\ ha^{-1}$)	($l\ ha^{-1}$)	($l\ ha^{-1}$)
1	0.47	0	0.26	0
2	0.16	1.06	0.33	0.95
3	0.64	0	0.34	0
4	0.64	1.53	0	0
5	0.23	1.53	0.50	0
6	0.23	1.53	0.50	0.76
7	0.16	1.06	0.33	1.78

The treatments at Imishli were applied on 19 September and the second on 25 September. The treatments applied at Goran performed poorly, leading to the decision to increase rates of defoliant and boll opener for the trial at Imishli. Treatments at Imishli were applied under favorable conditions of warm temperatures and no precipitation.

Table 4.19 Analysis of variance of fiber traits as measured by HVI from the defoliation trial at Imishli, Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Rep	2	0.07	1.05	0.19	0.27	2.68	5.67*	792.15	6.60*	0.02	0.25
Treatment	6	0.03	0.43	0.87	1.24	0.89	1.87	180.87	1.51	0.21	2.15
Error	12	0.07		0.70		0.47		120.06		0.10	

Table 4.20 Cotton fiber quality as measured by HVI from the defoliation trial at Imishli, Azerbaijan, in 2019.

Treatment	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	5.0	30.0	85.4	275	7.1
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	5.0	29.6	84.2	285	6.7
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	5.2	29.6	84.2	278	6.8
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	5.0	29.9	84.7	283	6.8
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	4.9	29.5	84.3	282	6.5
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	5.0	30.5	83.6	262	7.0
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	5.1	28.7	84.6	276	6.4
Mean	5.0	29.7	84.4	277	6.7
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	5.1	2.8	0.8	4.0	4.6

Fiber quality traits measured by HVI were not different among treatments. It is likely that cotton at Imishli had begun to experience slow growth at the time defoliation applications were made which resulted in similar fiber quality ratings. Lower rates of Baystar and Son Final resulted in similar fiber quality for all other treatments, and should be considered as an alternative to minimize product usage and cost of applications.

Table 4.21 Fiber color and trash as measured by HVI from the defoliation trial at Imishli, Azerbaijan, in 2019.

Treatment	Reflectance (Rd)	Yellowness (+b)	Leaf Grade
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	70.4	8.5	7.3
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	73.1	8.2	6.0
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	71.5	8.6	7.0
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	69.3	8.5	7.7
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	72.4	8.3	6.7
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	69.7	8.3	7.3
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	71.8	8.3	6.0
Mean	71.2	8.4	6.9

The color and grades of samples were not as good at Imishli compared to the samples from Goran (Table 4.20). High leaf grades at Imishli can be attributed to the weediness of the plots and as a result of using mechanical harvesters. Leaf grades of samples can be reduced through cleaning practices at the gin. Cleaning seed cotton at the gin is effective for removing larger foreign material but can cause negative effects on the fiber quality (Hardin et al. 2018).

Table 4.22 Analysis of variance of fiber traits as measured by AFIS from the defoliation trial at Imishli, Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Nep/g		UQL		SFC (n)		Fineness		IFC		Maturity	
		MS	F	MS	F	MS	F	MS	F	MS	F	MS	F
Rep	2	523.00	3.31	0.15	0.10	13.45	1.91	5.76	0.11	0.06	0.08	0.0001	0.11
Treatment	6	200.76	1.27	0.91	0.58	8.52	1.21	37.52	0.72	0.95	1.26	0.0007	1.02
Error	12	158.17		1.57		7.04		52.10		0.75		0.0007	

Table 4.23 Cotton fiber quality as measured by AFIS from the defoliation trial at Imishli, Azerbaijan, in 2019.

Treatment	Nep/g	UQL	SFC (n)	Fineness	IFC	Maturity
	unit	mm	%	m/tex	%	ratio
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	55.0	31.0	23.0	186	5.2	0.94
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	60.7	31.2	24.9	186	4.9	0.94
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	65.7	31.0	27.6	183	5.9	0.92
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	57.3	30.4	26.3	181	6.2	0.91
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	72.3	30.1	27.3	179	6.3	0.91
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	75.3	31.5	27.7	177	6.2	0.90
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	55.7	30.1	26.2	184	5.3	0.93
Mean	63.1	30.8	26.2	182	5.7	0.92
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	19.9	4.1	10.1	4.0	15.2	2.8

AFIS data provided measurements of fiber quality that could not be determined from HVI measurements. AFIS measurements were instrumental in identifying treatments that resulted in poorer quality fibers. Treatments with lower rates of Baystar in the second application showed lower Neps (Treatments #4 and #1) (Table 4.23). Other interactions such as precipitation and sunlight, which were not recorded, could be contributing to changes in cotton production and fiber quality (Sawan, 2018).

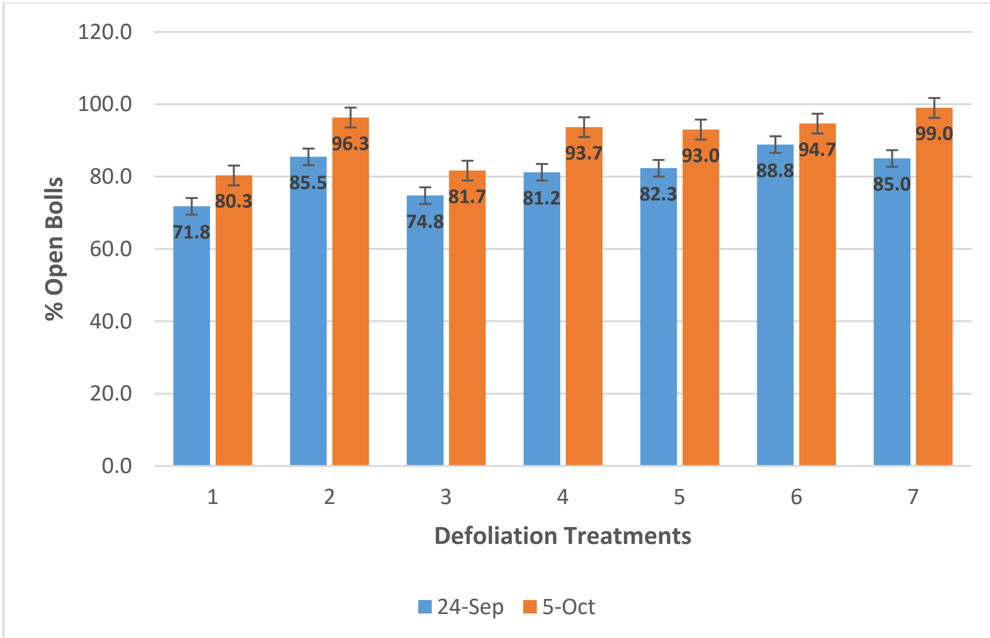

Figure 4. Percent open boll from the defoliation trial at Imishli, Azerbaijan, 2019.

At Imishli, defoliation treatments were first applied on 19 September, and again on 25 September. By 5 October, the majority of treatments had reached a desired level of open bolls, except Treatments #1 and #3 (Figure 5). These treatments did not contain Son Final and failed to reach a desired percentage of open bolls. This suggests that tank mixes containing boll opening products are important in reaching optimal harvest conditions. Treatments #2 and #7 contained identical low initial rates of Baystar (0.16 liters per hectare) and Son Final (1.06 liters per hectare). Both treatments also had a second application of Baystar at a rate of (0.33 liters per hectare), but Treatment #2 utilized almost half the amount of Son Final contained in Treatment #7, and resulted in an almost identical percentage of open bolls. This suggests that split applications are the best strategy and second applications of Son Final could be applied at a reduced rate and still reach optimal harvest conditions.

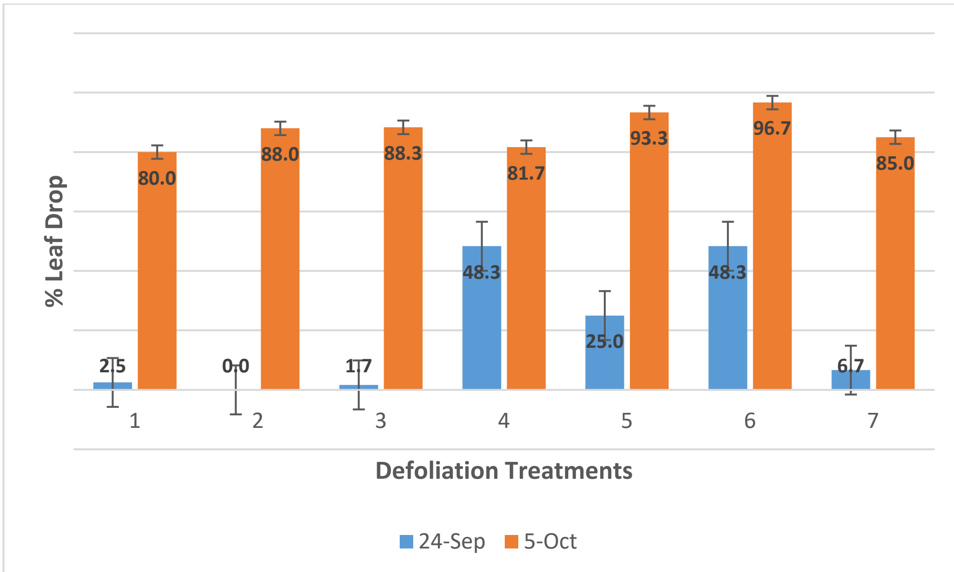

Figure 5 Percent leaf drop from the defoliation trial at Imishli, Azerbaijan, 2019.

Treatments that included high rates of Son Final (1.53 liters per hectare) had the fastest rate of defoliation (Treatments #4, #5, #6) (Figure 6). Treatment #4 contained a high initial application of Baystar and Son Final, but there was not a second application, and it ranked among the poorest treatments for percent leaf drop that was measured on 5 October (Figure 6). Treatments that utilized split applications of Baystar and Son Final out-performed other treatments which would suggest that split applications work best to reach desired levels of defoliated cotton.

Table 4.24 Treatments in the defoliation trial at College Station, Texas, in 2020.

Treatment	11 August		17 August	
	Ginstar ($l\ ha^{-1}$)	Super Boll ($l\ ha^{-1}$)	Ginstar ($l\ ha^{-1}$)	Super Boll ($l\ ha^{-1}$)
1	0.47	0.00	0.26	0.00
2	0.16	1.06	0.33	0.95
3	0.64	0.00	0.34	0.00
4	0.64	1.53	0.00	0.00
5	0.23	1.53	0.50	0.00
6	0.23	1.53	0.50	0.76
7	0.16	1.06	0.33	1.78

Travel restrictions resulted in trials being halted in Azerbaijan. Similar trials were then conducted at the Texas A&M Research farm in College Station, Texas. Defoliation rates were based on treatment rates applied at Imishli, Azerbaijan in 2019.

Table 4.25 Analysis of variance of fiber traits as measured by HVI from the defoliation trial at College Station, Texas, in 2020 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Rep	3	0.02	1.21	0.37	1.07	0.69	1.37	152.23	2.45	0.01	1.28
Treatment	6	0.03	1.77	0.19	0.54	0.28	0.56	15.31	0.25	0.02	1.49
Error	18	0.02		0.35		0.51		62.10		0.01	

Table 4.26 Cotton fiber quality as measured by HVI from the defoliation trial at College Station, Texas, in 2020.

Treatment	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	4.6	29.3	82.7	296	5.6
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	4.5	29.0	83.1	295	5.6
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	4.5	29.3	83.2	294	5.6
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	4.5	28.8	82.8	292	5.7
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	4.7	28.8	83.0	291	5.8
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	4.5	28.9	83.3	296	5.6
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	4.4	29.1	83.4	292	5.7
Mean	4.5	29.0	83.1	294	5.7
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	2.8	2.0	0.9	2.7	1.8

Fiber traits measured by HVI from the samples collected at College Station differed only slightly. This suggests that the timing of the application and treatments had minimal effect on fiber quality. Minimal rainfall and high temperatures late in the growing season probably resulted in the crop shutting down early.

Table 4.27 Fiber color and trash as measured by HVI from the defoliation trial at College Station, Texas, in 2020.

Treatment	Reflectance (Rd)	Yellowness	Leaf Grade
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	78.5	9.2	5.5
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	79.0	9.6	3.5
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	77.6	9.3	5.0
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	78.4	9.5	4.5
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	78.7	9.4	4.5
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	79.1	9.5	4.3
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	78.5	9.4	4.5
Mean	78.5	9.4	4.5

Treatments had minimal differences among reflectance and yellowness grades. It is interesting to note that samples collected from mechanically harvested cotton resulted in cleaner leaf grades, compared to treatments harvested identically at Imishli, Azerbaijan (Table 4.21). Trials in College Station were thoroughly weeded throughout the season which helped to contribute to a cleaner leaf grade. A well-managed crop with an intense weed control program results in cleaner leaf grades.

Table 4.28 Analysis of variance of fiber traits as measured by AFIS from the defoliation trial at College Station, Texas, in 2020 (* significant at the .05 probability level).

Source	df	Nep/g		UQL		SFC (n)		Fineness		IFC		Maturity	
		MS	F	MS	F	MS	F	MS	F	MS	F	MS	F
Rep	3	1371.71	1.68	0.19	0.85	20.31	1.87	14.95	1.45	0.09	0.67	0.0001	0.78
Treatment	6	1313.33	1.61	0.19	0.87	3.46	0.32	5.73	0.55	0.11	0.72	0.0001	0.61
Error	18	817.82		0.22		10.86		10.34		0.14		0.0002	

Table 4.29 Cotton fiber quality as measured by AFIS from the defoliation trial at College Station, Texas, in 2020.

Treatment	Nep/g	UQL	SFC (n)	Fineness	IFC	Maturity
	unit	mm	%	m/tex	%	ratio
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	85.5	30.2	19.1	174	5.2	0.95
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	103.3	30.2	19.1	171	5.6	0.94
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	113.5	30.2	19.9	172	5.3	0.94
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	112.8	30.2	18.8	171	5.6	0.93
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	105.5	30.2	18.8	173	5.3	0.94
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	129.3	29.8	18.5	172	5.5	0.94
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	141.3	30.5	21.2	172	5.3	0.93
Mean	113.0	30.2	19.4	172	5.4	0.94
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	25.3	1.6	17.0	1.9	7.1	1.4

There was no significance among treatments for fiber quality measured by AFIS. Treatments that contained second applications of Son Final contained the highest rates of neps. All other fiber quality measurements had minimal differences among treatments. AFIS measurements showed differences among fiber quality that HVI failed to detect.

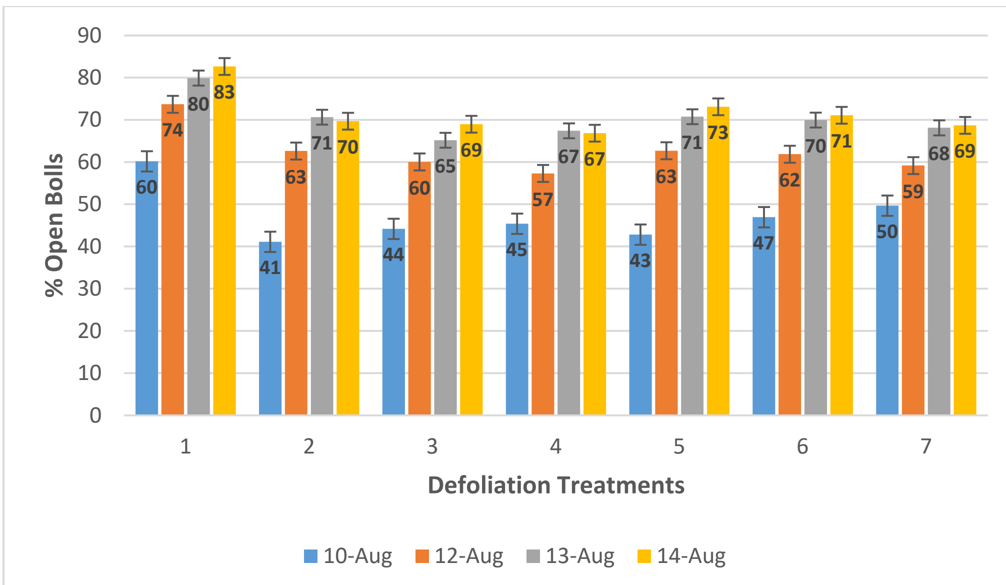

Figure 6 Percent open boll averages of replicate treatment plots at College Station, Texas, 2020.

Defoliation treatments in College Station appeared to work similarly. The field used in the test was non-irrigated. This resulted in cotton having reduced amounts of vegetation compared to cotton grown with irrigation or adequate rainfall. Utilizing the least expensive treatment rate worked just as well as the most expensive, suggesting that low rates would provide the same outcome for percentage of open bolls.

Table 4.30 Analysis of variance of fiber traits as measured by HVI for combined defoliation trials in Azerbaijan and College Station, in 2019 and 2020 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Location	1	3.08	73.08*	5.17	10.85	22.81	11.52*	3229.40	7.07*	14.21	102.19*
Rep(Location)	5	0.04	1.09	0.30	0.61	1.49	3.02*	408.21	4.78*	0.02	0.39
Treatment	6	0.02	0.48	0.49	0.73	0.27	0.27	86.42	0.65	0.09	0.52
Location*Trt	6	0.04	1.07	0.67	1.37	0.98	2.00	133.61	1.57	0.17	3.68*
Error	30	0.04		0.49		0.49		85.33		0.05	

Table 4.31 Cotton fiber quality as measured by HVI for combined defoliation trials in Azerbaijan and College Station, in 2019 and 2020.

Treatment	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	4.8	29.6	83.8	287	6.2
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	4.7	29.3	83.6	291	6.1
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	4.8	29.4	83.7	287	6.1
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	4.7	29.3	83.6	288	6.2
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	4.8	29.1	83.6	287	6.1
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	4.7	29.6	83.4	281	6.2
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	4.7	29.0	83.9	285	6.0
Mean	4.7	29.3	83.7	287	6.1
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	4.0	2.4	0.8	3.2	3.5

Table 4.32 Fiber color and trash as measured by HVI for combined defoliation trials in Azerbaijan and College Station, in 2019 and 2020.

Treatment	Reflectance (Rd)	Yellowness (+b)	Leaf Grade
1) B(0.47)+S(0.00) & B(0.26)+S(0.00)	75.0	8.9	6.3
2) B(0.16)+S(1.06) & B(0.33)+S(0.95)	76.5	9.0	4.6
3) B(0.64)+S(0.00) & B(0.34)+S(0.00)	75.0	9.0	5.9
4) B(0.64)+S(1.53) & B(0.26)+S(0.00)	74.5	9.1	5.9
5) B(0.23)+S(1.53) & B(0.50)+S(0.00)	76.0	8.9	5.4
6) B(0.23)+S(1.53) & B(0.50)+S(0.76)	75.1	8.9	5.6
7) B(0.16)+S(1.06) & B(0.33)+S(1.78)	75.6	8.9	5.1
Mean	75.4	9.0	5.5

Defoliation trials did not show significant differences for fiber data analyzed. However, data collected from both locations did provide insight into the effect of late season applications of harvest aids. After analyzing fiber data for treatments, the effect of chemicals did not negatively impact fiber measurements. Since late season applications of herbicides did not affect fiber quality, the use of other herbicides as harvest-aids could be considered. Systemic herbicides such as glyphosate, would end the crop, remove the problem of regrowth that occurs with cotton, and desiccate green leaves that would otherwise be harvested (Cathey and Barry, 1977).

4.3. Nitrogen Fertilizer Trials

Nitrogen fertilizer trials had few major differences among the agronomic data when analyzed across locations combining both locations (Table 4.33). The MKT Farms at Goran and Imishli utilize P200 as their standard practice on their cotton crops. The P200 and P300 treatments were among the highest yielding treatments while the unfertilized 0N treatment was among the lowest. Their current program offers the highest yields, but if fertilizer rates were slightly reduced, yields would not be drastically affected, and input costs would decline. A year-by-year cost benefit analysis maybe be prudent for Azerbaijan cotton production that accounts for the cost of fertilizer versus the projected price of cotton fiber.

Table 4.33 Analysis of variance of yield and agronomic characteristics from the combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Seedcotton		Lint		1st Lint %		2nd Lint %		% 1st Har	
		MS	F	MS	F	MS	F	MS	F	MS	F
Loc	1	39,335,493	74.61	8,176,280	89.16	33.1	23.43	37.3	12.84	14.10	0.2
Rep(Loc	6	1,703,862	3.23*	298,647	3.26*	1.03	0.73	4.06	1.40	122.2	1.8
Trt	8	862,487	1.64	161,069	1.76	1.40	0.99	2.47	0.85	10.40	0.1
Trt*Loc	8	589,359	1.12	105,066	1.15	0.42	0.29	2.61	0.90	59.22	0.8
Error	4	527,226		91,705		1.41		2.91		66.81	

Table 4.34 Yield characteristics of the combined nitrogen trials in Azerbaijan, in 2019.

Treatments	Seedcotton	Lint	1st Harvest	2nd Harvest	% 1st Harvest
	Kg Ha-1	Kg Ha-1	Lint %	Lint %	(earliness)
P100	3,282	1,416	50.0	40.1	87.4
P200	3,508	1,506	43.0	39.8	87.3
P300	3,289	1,417	43.0	39.6	86.3
0N	2,685	1,151	42.8	40.1	83.9
50N	3,045	1,301	42.6	39.7	83.9
100N	2,952	1,231	41.8	39.1	85.1
150N	2,598	1,122	43.0	39.8	86.0
200N	2,936	1,249	42.3	40.2	86.6
250N	2,583	1,114	42.8	38.5	85.1
Mean	2,986	1,279	42.7	39.6	85.9
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	24.3	23.7	2.8	4.3	9.5

After analyzing HVI fiber data across locations, we found significant differences across treatments for micronaire (Table 4.35). Although there is evidence from previous studies to support the conclusion that nitrogen deficiency can negatively impact fiber length, strength, and micronaire (Read et al. 2006); much of the HVI fiber measurements from our trial suggested minimal impacts from fertilizer upon fiber quality. Perhaps nitrogen carry-over in the soil from previous crops had an impact on fiber samples collected from Imishli and Goran. Another potential explanation, could be poorly timed irrigation and/or weed control, occurring especially at Imishli.

Table 4.35 Analysis of variance of fiber traits as measured by HVI of the first harvest for combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Loc	1	12.02	374.23*	205.59	244.39*	44.65	32.48*	8,694.45	25.28*	86.24*	666.37*
Rep(loc	6	0.12	3.96*	2.07	2.47*	3.36	2.45*	379.48	1.10	0.50*	3.89*
Trt	8	0.072	2.25*	0.52	0.62	2.28	1.66	212.45	3.08	0.065	0.50
Trt*Loc	8	0.031	0.97	1.13	1.34	0.35	0.26	68.88	0.20	0.19	1.54
Error	48	0.03		0.84		1.37		343.97		0.12	

Table 4.36 Cotton fiber quality of the first harvest as measured by HVI for combined nitrogen trials in Azerbaijan, in 2019.

Treatments	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
P100	4.7	30.2	85.1	292	7.3
P200	4.8	30.3	85.7	298	7.2
P300	4.7	30.6	85.6	297	7.1
0N	4.6	30.2	85.0	290	7.3
50N	4.5	30.3	85.0	283	7.3
100N	4.6	30.1	84.7	289	7.1
150N	4.7	29.6	83.8	296	7.2
200N	4.6	30.0	85.0	291	7.2
250N	4.7	30.0	85.1	289	7.1
Mean	4.7	30.2	85.0	292	7.2
LSD (0.05)	0.19	N.S.	N.S.	N.S.	N.S.
C.V.,%	3.8	3.0	1.4	6.4	5.0

Similar to the first harvest, the second harvest shows significance for micronaire values among treatments measured by HVI (Table 4.37). Micronaire values decreased in the second harvest which is likely a result of less stress (heat, drought, or water) impacted on the second harvest of fiber samples (Hake et al., 1996).

Table 4.37 Analysis of variance of fiber traits as measured by HVI of the second harvest for combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Location	1	9.61	70.81*	76.93	65.78*	10.35	4.54*	35.92	0.07	77.71	280.82*
Rep(location)	6	0.23	1.70	0.43	0.37	1.91	0.84	813.33	1.64	0.46	1.68
Treatment	8	0.38	2.81*	1.07	0.92	1.24	0.54	191.52	0.39	0.29	1.04
Treatment*Loc	8	0.25	1.86	1.18	1.01	2.74	1.20	324.93	0.65	0.13	0.48
Error	48	0.14		0.169		2.279		496.85		0.276	

Table 4.38 Cotton fiber quality of the second harvest as measured by HVI for combined nitrogen trials in Azerbaijan, in 2019.

Treatments	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
P100	4.3	30.3	84.6	299	8.2
P200	4.2	31.1	84.9	292	8.2
P300	4.2	30.7	84.8	299	8.1
0N	4.1	31.0	85.5	300	7.7
50N	3.7	31.2	85.4	288	8.2
100N	3.9	31.3	85.5	293	8.1
150N	4.0	31.4	85.6	290	8.3
200N	4.0	31.3	85.6	298	8.1
250N	3.7	31.4	85.3	301	8.3
Mean	4.0	31.1	85.2	295	8.1
LSD (0.05)	0.37	N.S.	N.S.	N.S.	N.S.
C.V.,%	9.0	3.4	1.7	7.5	6.4

Fiber measured by AFIS revealed an inconsistent trend as to the effect of nitrogen rates upon fiber quality from the first harvest (Table 4.41). Other variables that were not measured could be the result of discrepant results. Residual effects of fertilizer from previous crops grown resulted in inconsistent findings, and do not allow for a conclusion to an optimal rate of nitrogen. Conducting long-term fertilizer trials would mitigate the impact of extraneous variables, provide a more accurate representation of the effects of treatments applied, and more accurately evaluate the long-term sustainability of the applied fertilizer treatments (Johnston, 2018).

Table 4.39 Analysis of variance of fiber traits as measured by AFIS of the first harvest for combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Nep/g		UQL		SFC (n)	
		MS	F	MS	F	MS	F
Location	1	22,472.00	88.84*	175.85	298.48*	68.25	7.88*
Rep(location)	6	952.07	3.76*	3.04	5.15*	27.01	3.12*
Treatment	8	780.22	3.08*	0.66	1.12	12.04	1.39
Treatment*Loc	8	60.22	0.24	1.06	1.80	9.77	1.13
Error	48	252.96		0.59		8.66	

Table 4.40 Analysis of variance of fiber traits as measured by AFIS of the first harvest for combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Fineness		IFC		Maturity	
		MS	F	MS	F	MS	F
Location	1	13,888.89	482.24*	39.90	142.33*	0.076	180.86*
Rep(location)	6	83.51	2.90*	0.70	2.49*	0.001	2.44*
Treatment	8	30.68	1.07	0.42	1.49	0.0005	1.11
Treatment*Loc	8	46.01	1.60	0.42	1.48	0.0004	1.01
Error	48	28.80		0.28		0.0004	

Table 4.41 Cotton fiber quality of the first harvest as measured by AFIS for combined nitrogen trials in Azerbaijan, in 2019.

Treatments	Neps/g	UQL	SFC (n)	Fineness	IFC	Maturity
	unit	mm	%	m/tex	%	ratio
P100	58.2	30.6	8.6	178	5.6	0.9
P200	59.5	31.2	8.2	177	5.6	0.9
P300	69.3	31.4	7.8	175	6.0	0.9
0N	63.5	31.0	7.8	177	5.6	0.9
50N	59.6	31.1	8.5	174	5.7	0.9
100N	83.2	31.2	9.0	172	6.1	0.9
150N	63.0	30.4	9.1	176	6.2	0.9
200N	83.0	31.0	9.4	175	5.9	0.9
250N	60.6	31	8.1	177	5.6	0.9
Mean	66.7	31.0	24.6	176	5.8	0.9
LSD (0.05)	15.99	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	23.8	2.4	12.0	3.1	9.1	2.2

Similar to the results observed from the first harvest, there were few trends in fiber quality. Nitrogen treatments had minimal effect of AFIS fiber properties for the combined trials (Table 4.42 and 4.43). It is interesting to note that Azerbaijan has a short growing season for cotton, which does allow for fewer inputs such as irrigation than regions with longer growing seasons. Azerbaijan nitrogen rates should be selected based on treatments resulting in the earliest crop maturity.

Table 4.42 Analysis of variance of fiber traits as measured by AFIS of the second harvest for combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Nep/g		UQL		SFC (n)	
		MS	F	MS	F	MS	F
Location	1	22,613.56	41.01*	39.89	33.39*	19.22	1.73
Rep(location)	6	1,359.56	2.47*	1.37	1.14	31.31	2.82*
Treatment	8	801.05	1.45	1.48	1.24	26.22	2.36*
Treatment*Loc	8	417.65	0.76	1.04	0.87	11.34	1.02
Error	48	551.43		1.19		11.11	

Table 4.43 Analysis of variance of fiber traits as measured by AFIS of the second harvest for combined nitrogen trials in Azerbaijan, in 2019 (* significant at the .05 probability level).

Source	df	Fineness		IFC		Maturity	
		MS	F	MS	F	MS	F
Location	1	7,729.39	115.22*	42.47	50.59*	0.075	88.50*
Rep(location)	6	226.99	3.38*	2.54	3.02*	0.003	3.78*
Treatment	8	122.14	1.82	1.24	1.47	0.001	1.67
Treatment*Loc	8	70.33	1.05	0.73	0.87	0.001	0.87
Error	48	67.08		0.84		0.001	

Table 4.44 Cotton fiber quality of the second harvest as measured by AFIS for combined nitrogen trials in Azerbaijan, in 2019.

Treatments	Neps/g	UQL	SFC (n)	Fineness	IFC	Maturity
	unit	mm	%	m/tex	%	ratio
P100	78.1	31.4	24.3	169	6.7	0.9
P200	71.5	32.6	23.9	166	6.8	0.9
P300	66.3	31.4	20.6	167	6.8	0.9
0N	70.3	31.7	25.3	165	6.6	0.9
50N	90.2	31.6	27.3	158	7.6	0.9
100N	87.8	31.8	24.9	163	6.7	0.9
150N	66.5	32.4	23.3	164	6.9	0.9
200N	78.3	32.2	23.9	163	7.3	0.9
250N	91.6	31.9	25.3	157	7.6	0.9
Mean	77.9	31.9	24.3	163	7.0	0.9
LSD (0.05)	N.S.	N.S.	3.35	N.S.	N.S.	N.S.
C.V.,%	30.1	3.4	13.7	5.0	13.0	3.3

At College Station, applications of urea had no significant impact on fiber quality when measured by HVI (Table 4.45 and 4.46). Fiber measurements collected from College Station trials had values in the non-discount range for the entire test (Table 4.46). This would lead to the assumption that the nitrogen trial at College Station did not suffer from deficiencies. The previous crop at College Station was grain sorghum. It is possible that there was nitrogen carry-over in the soil that aided fiber development all treatments within the trial.

Table 4.45 Analysis of variance of fiber traits as measured by HVI for the nitrogen trial at College Station, Texas, in 2020 (* significant at the .05 probability level).

Source	df	Micronaire		Length		Uniformity		Strength		Elongation	
		MS	F	MS	F	MS	F	MS	F	MS	F
Rep	1	0.009	0.33	3.10	8.57*	3.97	8.24*	103.30	0.87	0.008	0.79
Treatment	8	0.018	0.70	0.62	1.70	0.81	1.69	199.84	1.69	0.031	3.25
Error	8	0.02		0.36		0.48		118.41		0.01	

Table 4.46 Cotton fiber quality as measured by HVI from the nitrogen trial at College Station, Texas, in 2020.

Treatment	Micronaire	Length	Uniformity	Strength	Elongation
	unit	mm	%	kNm/kg	%
0N	4.3	28.8	84.6	326	6.2
50N	4.4	29.3	83.2	325	5.9
100N	4.4	29.5	84.4	338	5.9
150N	4.2	28.5	83.4	329	6.0
200N	4.3	29.9	84.3	342	6.0
250N	4.4	28.7	83.3	314	5.9
Mean	4.3	29.2	83.8	329	6.0
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.,%	3.7	2.1	0.8	3.3	1.6

There was significance for UQL measurements from AFIS measured fiber data (Table 4.47), but there was no particular trend among treatments to provide any fertilizer recommendations. Observations made throughout the growing season showed cotton was grown under minimal stress, which allowed for optimal fiber development among all treatments.

Table 4.47 Analysis of variance of fiber traits as measured by AFIS for the nitrogen trial at College Station, Texas, in 2020 (* significant at the .05 probability level).

Source	df	Nep/g		UQL		SFC (n)	
		MS	F	MS	F	MS	F
Rep	1	800.33	0.77	2.15*	13.16	1.76	0.66
Treatment	5	537.93	0.52	1.36*	8.34	1.10	0.41
Error	5	1043.73		0.16		2.66	

Table 4.48 Analysis of variance of fiber traits as measured by AFIS for the nitrogen trial at College Station, Texas, in 2020 (* significant at the .05 probability level).

Source	df	Fineness		IFC		Maturity	
		MS	**F**	**MS**	**F**	**MS**	**F**
Rep	1	12.00	0.51	0.067	1.06	0.000008	0.06
Treatment	5	14.33	0.61	0.09	1.57	0.000155	1.21
Error	5	23.60		0.04		0.000128	

Table 4.49 Cotton fiber quality as measured by AFIS from the nitrogen trial at College Station, Texas, in 2020.

Treatments	Neps/g	UQL	SFC (n)	Fineness	IFC	Maturity
	unit	mm	%	m/tex	%	ratio
0N	111.0	30.6	15.6	175	5.4	0.9
50N	96.5	30.4	14.0	172	5.4	0.9
100N	79.0	31.2	14.2	175	5.4	0.9
150N	97.0	30.6	15.0	168	5.6	0.9
200N	74.5	32.1	14.0	173	5.2	1.0
250N	68.0	29.7	15.5	172	5.9	0.9
Mean	87.7	30.8	14.7	172	5.5	0.9
LSD (0.05)	N.S.	1.03	N.S.	N.S.	N.S.	N.S.
C.V.,%	36.8	1.3	11.1	2.8	4.6	1.2

The nitrogen trial at College Station did not have any significant differences for yield (Table 4.50). Observations made throughout the growing season showed the field was not under stress. In depth soil testing prior to planting would help to determine if there is any carry-over nitrogen in the soil from previous crops.

Table 4.50 Analysis of variance of yield measurement for the nitrogen trial at College Station, Texas, in 2020 (* significant at the .05 probability level).

Source	df	Seedcotton	
		MS	F
Rep	1	573,294	10.89*
Treatment	5	61,869	1.17
Error	5	52,659	

Table 4.51 Yield characteristics of the nitrogen trial in College Station, Texas, in 2020.

Treatments	Seedcotton
	Kg Ha^{-1}
0N	4032
50N	3994
100N	4015
150N	3607
200N	3785
250N	4028
Mean	3910
LSD (0.05)	N.S.
C.V.,%	5.86

5. CONCLUSION

5.1. Cotton Variety Trials

Cotton variety trials planted in Goran and Imishli were conducted to help determine which varieties are better suited for each location and production environment. All varieties planted in the trials produced high quality fiber and were high yielding. Future knowledge gained about varieties planted should include observations of early maturity, disease resistance, lint yield, and fiber quality. New varieties should continually be sourced from breeding programs and implemented in test trials. Having access to varieties best suited to the growing regions in Azerbaijan could allow Azerbaijani farmers to improve yields and help the country to be competitive in the international cotton trading market in terms of cost of production and quality of raw fiber.

5.2. Cotton Defoliation Trials

Defoliation trials have the most potential to beneficially impact the entire cotton industry in Azerbaijan. Substantial amounts of energy are spent drying and cleaning poorly defoliated cotton in Azerbaijan. In addition, fiber quality is impacted by poor color, fiber breakage, and poor seed quality due to low quality defoliation practices. Selecting rates of defoliants and boll-openers best suited for the growing region could help to reduce the amount of labor involved after harvest and lead to cleaner seedcotton delivered to gins. Split applications tended to result in a better defoliation and increased the rate of boll opening than single applications. Utilizing other chemistries such as glyphosate as a harvest-aid have shown to reduce some of the problems that occur during harvest, such as regrowth and green leaves that remain on the plant. An added benefit of glyphosate as a harvest-aid is its classification as a systemic herbicide, this would help in the control of weed populations and weed seed banks that are present in the field.

5.3. Nitrogen Fertilizer Trials

Soil testing should be done prior to planting to understand what soil amendments are currently in the soil. Nitrogen carry-over, as well as other nutrients, from previous years could affect yield and fiber quality. Based upon the data from our trials, fiber quality did not seem to be affected by our treatments. There appears to be a possible reservoir of nitrogen left in the soil from previous crops. Excessive nitrogen application can cause the crop to have unnecessary vegetative growth, which attracts pests, and cause delayed harvest timing. Nitrogen carry-over is highly possible because the areas in which the trials are located do not receive measurable amounts of rainfall, which would cause mobile nutrients to be leached. Determining optimal nitrogen rates helps to maximize yield, reduce unnecessary inputs, and minimize negative impacts upon the environment.

REFERENCES

Aliyeva, S., & Ismayilov, N. (2019). STUDY OF QUALITY OF THE IRRIGATION CANALS IN AZERBAIJAN. Science Review. https://rsglobal.pl/index.php/sr/article/view/1012/991

Armenia, Azerbaijan and Russia . (2020). BBC News. https://www.bbc.com/news/world-europe-54882564

"Azerbaijan and the Silk Road." Advantour, https://www.advantour.com/silkroad/azerbaijan.htm. Accessed 17 Apr. 2021.

Azerbaijan/Armenia: Scores of civilians killed by indiscriminate use of weapons in conflict over Nagorno-Karabakh | Amnesty International. (2021). Amnesty International . https://www.amnesty.org/en/latest/news/2021/01/azerbaijan-armenia-scores-of-civilians-killed-by-indiscriminate-use-of-weapons-in-conflict-over-nagorno-karabakh/

Azerbaijan. (n.d.). FAO. Retrieved May 9, 2021, from http://www.fao.org/3/y2722e/y2722e0j.htm

Azerbaijan profile - Timeline. (2018). BBC News. https://www.bbc.com/news/world-europe-17047328

Azerbaijan works towards consolidating land. (2019). FAO. http://www.fao.org/europe/news/detail-news/en/c/1206387/

Barber, L. T. (2013). Mid-South cotton defoliation guide. https://cdm16039.contentdm.oclc.org/digital/collection/p266101coll7/id/26346/

Cathey, G. W., & Barry, H. R. (1977). Evaluation of Glyphosate as a Harvest-Aid Chemical on Cotton1. Agronomy Journal, 69(1), 11–14. https://doi.org/10.2134/AGRONJ1977.00021962006900010003X

Colquhoun, J. (2003). How long do weed seeds survive in the soil? | OSU Extension Service. https://extension.oregonstate.edu/news/how-long-do-weed-seeds-survive-soil

Dunn, R. (1952). Cotton in the Middle East. National Cotton Council.

Emirdirek, H. (n.d.). Culture of Azerbaijan. Countries and Their Cultures. Retrieved May 8, 2021, from https://www.everyculture.com/A-Bo/Azerbaijan.html

Fernholz, E. (n.d.). The Russian Revolution of 1917. Marquette University. Retrieved June 28, 2021, from https://academic.mu.edu/meissnerd/russian-rev.htm

Ferrell, J. A., Macdonald, G. E., & Devkota, P. (n.d.). Weed Management in Cotton 1. Retrieved February 17, 2022, from https://edis.ifas.ufl.edu

Ghosh, A., & Zhaowen, G. (n.d.). The Silk Roads Programme. UNESCO. Retrieved February 2, 2021, from https://en.unesco.org/silkroad/content/republic-azerbaijan-supports-unesco-silk-road-online-platform

Hague, S. (2019, July 9). Azerbaijan History and Agricultural Production. personal.

Hake, K. D., Bassett, D. M., Kerby, T. A., & Mayfield, W. D. (1996). Producing quality cotton. Cotton production manual. University of California, Department of Agriculture and Natural Resources, Publication, 3352, 134-149.

Hansen, V. (2015). The Silk Road: A New History. Oxford University Press.

Hardin Iv, R. G., Barnes, E. M., Valco, T. D., Martin, V. B., Clapp, D. M., Hardin, R. G., & Valco, T. D. (2018). ENGINEERING AND GINNING Effects of Gin Machinery on Cotton Quality. The Journal of Cotton Science, 22, 36–46.

Hons, F. M., McFarland, M. L., Lemon, R. G., Nichols, R. L., Boman, R. K., Saladin, V. A., Mazac, F. J., Jahn, R. L., & Stapper, J. R. (2015). Managing Nitrogen Fertilization In Cotton.

Ibrahimov, A. (2016). Impact of Post-Soviet Transition on the Economy of Azerbaijan. Geopolitica.Info. https://www.geopolitica.info/impact-of-post-soviet-transition-the-economy-of-azerbaijan/

Johnston, A. E., & Poulton, P. R. (2018). The importance of long-term experiments in agriculture: their management to ensure continued crop production and soil fertility; the Rothamsted experience. European Journal of Soil Science, 69(1), 113–125. https://doi.org/10.1111/EJSS.12521

Kaufmann. (2016). Cotton Along the Silk Road. https://hist1800kkaufman.wordpress.com/2016/11/29/cotton-along-the-silk-road/

Khalilov, E. (2019, October 10). Azerbaijan: Managing Irrigation Systems through Water User Associations. The World Bank. https://www.worldbank.org/en/results/2019/10/10/azerbaijan-managing-irrigation-systems-through-water-user-associations

Khan, N., Han, Y., Xing, F., Feng, L., Wang, Z., Wang, G., Yang, B., Fan, Z., Lei, Y., Xiong, S., Li, X., & Li, Y. (2019). Plant Density Influences Reproductive Growth, Lint Yield and Boll Spatial Distribution of Cotton. Agronomy 2020, Vol. 10, Page 14, 10(1), 14. https://doi.org/10.3390/AGRONOMY10010014

Leep, R. H., & Meints, V. W. (1984). Conducting Successful Field Demonstration and Research Plots (Issue December).

Li Xinsheng, W. S. (2017). Agricultural exchanges and the Silk Road-SSCP. Chinese Social Sciences Today. http://www.csstoday.com/Item/4217.aspx

MKT Cotton LLC - The cotton brand name of Azerbaijan | LinkedIn. (n.d.). Retrieved March 22, 2022, from https://az.linkedin.com/company/mkt-cotton-llc

Mosely, Philip E. “Aspects of Russian Expansion.” American Slavic and East European Review, vol. 7, no. 3, JSTOR, Oct. 1948, p. 197, doi:10.2307/2492130

President Aliyev chairs meeting. (2019). Azernews. https://en.trend.az/azerbaijan/politics/3166236.html

Qamar, M. K. (2013). Azerbaijan. GFRAS. https://www.g-fras.org/en/world-wide-extension-study/130-world-wide-extension-study/asia/western-asia/283-azerbaijan.html

Raw Cotton in Azerbaijan. (n.d.). OEC. Retrieved May 9, 2021, from https://oec.world/en/profile/bilateral-product/raw-cotton/reporter/aze

Read, J. J., Reddy, K. R., & Jenkins, J. N. (2006). Yield and fiber quality of Upland cotton as influenced by nitrogen and potassium nutrition. European Journal of Agronomy, 24(3), 282–290. https://doi.org/10.1016/J.EJA.2005.10.004

Russian Revolution. (2009). https://www.history.com/topics/russia/russian-revolution

Sawan, Z. M. (2018). Climatic variables: Evaporation, sunshine, relative humidity, soil and air temperature and its adverse effects on cotton production. Information Processing in Agriculture, 5(1), 134–148. https://doi.org/10.1016/J.INPA.2017.09.006

Sharif, I., Aleem, S., Farooq, J., Rizwan, M., Younas, A., Sarwar, G., & Chohan, S. M. (2019). Salinity stress in cotton: effects, mechanism of tolerance and its management strategies. Physiology and Molecular Biology of Plants, 25(4), 807. https://doi.org/10.1007/S12298-019-00676-2

Silk Road. (2017). A&E. https://www.history.com/topics/ancient-middle-east/silk-road

Smith, C.W., Hague, S. and Jones, D. (2011), Registration of ‘Tamcot 73’ Upland Cotton Cultivar. Journal of Plant Registrations, 5: 273-278. https://doi.org/10.3198/jpr2010.12.0723crc

Soil Fertility . (n.d.). Advancing Cotton Education. Retrieved May 30, 2021, from https://www.cotton.org/tech/ace/soil-fertility.cfm

Spengler, R. (2016). Fruits of the Silk Road. ISAW. https://isaw.nyu.edu/events/archive/2016/fruits-of-the-silk-road

Stewart, S. (2012, August 22). Cotton Defoliation - Defoliation Products . UTcrops News. https://news.utcrops.com/2012/08/cotton-defoliation-defoliation-products/

Stuart, R. C. (1974). The Changing Role of the Collective Farm in Soviet Agriculture.

The Battle Of Stalingrad. (2020). Imperial War Museums. https://www.iwm.org.uk/history/what-you-need-to-know-about-the-battle-of-stalingrad

The State Statistical Committee of the Republic of Azerbaijan. (n.d.). Department of Information Technologies. Retrieved May 9, 2021, from https://www.stat.gov.az/source/agriculture/?lang=en

Russian Revolution Timeline. (n.d.). British Library. Retrieved April 1, 2021, from https://www.bl.uk/russian-revolution/articles/timeline-of-the-russian-revolution

van Berkum, S. (2017). Market and competitiveness analysis of the Azerbaijan agricultural sector: an overview. https://www.researchgate.net/publication/325145619_Market_and_competitiveness_analysis_of_the_Azerbaijan_agricultural_sector_an_overview

Wilson, J., & Rainey, J. (2015). Azerbaijan: A People from the Mists of Time. Geohistory. https://geohistory.today/azerbaijan/