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ENHANCING CROP PRODUCTIVITY USING BARLEY-COTTON DOUBLE CROPPING THROUGH MANAGEMENT STRATEGIES IN AN ARID AREA

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Abstract

In arid and semi-arid climates, agriculture faces numerous challenges such as water scarcity, climate change, and declining soil fertility. Double cropping systems have emerged as an effective strategy for improving resource use efficiency, enhancing food security, and building resilience in agricultural systems. In this study, we explored the ecophysiological aspects, quantitative and qualitative performance, and economic aspects of cotton double cropping alongside other field crops. From an agronomic perspective, double cropping increases total yield, improves water use efficiency, enhances soil structure, and promotes nutrient uptake. These systems extend vegetative cover and reduce fallow periods, thereby improving soil organic matter, facilitating biological nitrogen fixation, and minimizing erosion. Physiologically, crops in well-managed double cropping regimes often exhibit higher chlorophyll content, better root development, and improved photosynthetic efficiency, all of which contribute to greater biomass, more reproductive structures, and a higher harvest index. Economically, double cropping offers significant advantages by raising annual farm income, maximizing land and labor utilization, and reducing dependence on a single crop or market. However, implementation is often hindered by water limitations, short growing seasons, lack of access to quality inputs and technologies, labor shortages, and weak infrastructure and policy support. This study also examines how double cropping affects the growth, physiology, yield, and fiber quality of double cropped cotton. Findings indicate that cotton yield increases in the double cropping system if appropriate

planting dates are selected and agronomic management principles implemented. Planting time, residue management, and cultivar selection are critical to maintaining fiber properties such as lint length, strength, micronaire index and lint percentage. In some cases, delayed sowing can compromise fiber quality due to shortened growth periods. Overall, double cropping represents a key strategy for sustainable agricultural intensification in arid and semi-arid regions. Realizing its full potential will require localized research, farmer training, supportive policies, and advancement in irrigation and agronomic technologies. The future of double cropping will depend on the integration of innovation, effective governance, and community engagement to address food, environmental, and economic challenges in under cultivated areas.

Key words: Cotton, Double cropping, Fiber quality, Physiology, Water use efficiency, Yield.

Introduction

Agriculture in arid and semi-arid regions faces critical challenges in the 21st century due to climate change, diminishing water resources, and growing population pressure. In such regions, traditional monoculture systems often fail to sustainably meet the food, fiber, and income needs of rural communities. As a response to these constraints, double cropping, a form of multiple cropping in which two crops are grown consecutively on the same field within a single growing season or year, has gained increasing attention as a practical and resource-efficient alternative (Rana & Kukal, 2019; Gao et al., 2020). Double cropping systems (DCS) offer a viable strategy for increasing land-use intensity and total annual productivity without expanding the cultivated area-a crucial consideration in land-scarce and ecologically sensitive environments.

In arid climates, where the growing season is short and rainfall is erratic, adopting double cropping requires careful selection of short-duration, drought-tolerant cultivars and strategic management of limited water resources (Fig. 1). Studies have shown that under proper scheduling and soil moisture management, residual moisture from the first crop can be effectively utilized by the second crop, thereby improving water productivity (Gao et al., 2020; Kar et al., 2012). Additionally, the use of conservation agriculture practices such as minimum tillage, crop residue retention, and mulching can further enhance moisture conservation and system resilience (Rockström et al., 2014). From an environmental standpoint, double cropping systems can help stabilize agroecosystems by promoting biodiversity and reducing the dominance of single-species systems, which are often more vulnerable to pests and extreme weather events.

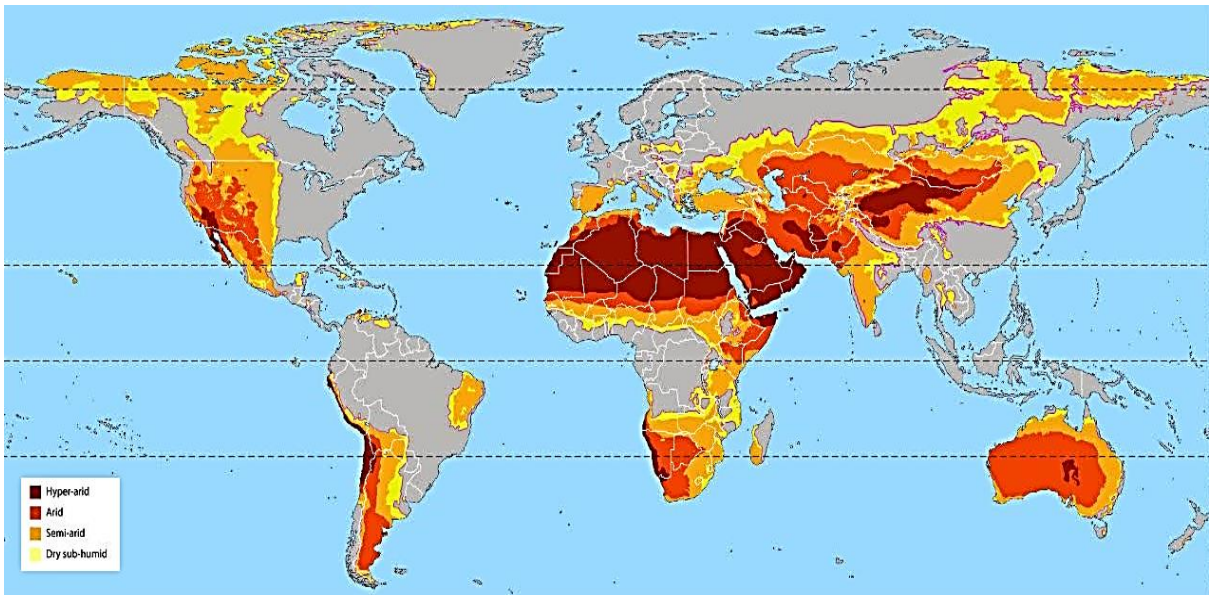


Figure 1. Map showing arid zones in the world.

Economically, double cropping can significantly increase net farm income by allowing farmers to take advantage of market fluctuations, stagger risks, and generate year-round employment. This is particularly relevant in developing countries where land and labor are often underutilized during the off-season (Waha et al., 2020; Jemberu et al., 2021). Socially, the adoption of double cropping can also contribute to food security, particularly in dryland rural communities that rely heavily on local production for staple foods.

Despite these benefits, the adoption of double cropping in dry regions remains uneven, largely due to constraints such as limited access to irrigation, low availability of suitable crop varieties, insufficient extension services, and a lack of policy incentives for diversified cropping systems. Furthermore, climate uncertainty introduces risks related to timing and harvest of the second crop, particularly when growing seasons overlap or rainfall patterns shift. To address these challenges and unlock the full potential of double cropping in arid climates, site-specific research and adaptive management strategies are essential. Such efforts should focus on identifying optimal crop sequences, enhancing agronomic practices, improving seed systems, and developing water-saving technologies. Additionally, supportive policies, access to credit, and farmer training are necessary to facilitate widespread adoption and ensure that double cropping systems contribute meaningfully to sustainable intensification. Moreover, integration with conservation agriculture practices, such as reduced tillage, cover cropping, and organic residue management can enhance the long-term sustainability of double cropping systems while mitigating environmental degradation (Smith et al., 2020; Rockström et al., 2014).

This study explores the performance and feasibility of double cropping systems under dryland conditions, focusing on their agronomic efficiency, resource use, economic viability, and ecological sustainability. By synthesizing recent empirical evidence and field-based

observations, the research aims to contribute to a better understanding of how double cropping can be effectively implemented in regions facing climatic and resource constraints, thereby supporting resilient and productive food systems.

Research overview

Double cropping in arid regions: a strategy to sustainable intensification

In arid and semi-arid regions, where agricultural production is often constrained by limited rainfall, short growing seasons, and declining soil fertility, double cropping offers a promising pathway for sustainable intensification. This approach enhances land productivity, maximizes resource use efficiency, and contributes to food security and income diversification, especially in areas prone to climate variability and land degradation (Waha et al., 2020; Ray et al., 2020). The success of double cropping in dry environments relies heavily on selecting short-duration, drought-tolerant varieties and optimizing the use of residual soil moisture after the harvest of the first crop. The inclusion of legumes in the cropping sequence further enhances soil nitrogen content through biological fixation, reducing the dependency on synthetic fertilizers and lowering production costs (Álvaro-Fuentes et al., 2024). Economically, double cropping contributes to higher net returns per hectare, allows farmers to better cope with market fluctuations, and creates employment opportunities throughout the year, which is particularly valuable in dryland communities where off-season labor demand is low. From an ecological perspective, the extended vegetative cover associated with double cropping helps reduce soil erosion, improve soil organic carbon levels, and increase overall system resilience in the face of climatic extremes (Basche & de Ramirèz., 2020; Waha et al., 2020).

1. Agronomic and ecological benefits

The adoption of double cropping offers multiple agronomic advantages. First and foremost, it increases total annual biomass and grain yields per unit area, compared to monoculture or fallow-based systems (Tadesse & Mengistu, 2021). Double cropping systems often yield more total biomass and economic return per unit land area than monocropping. In a 10-year study in the North China Plain, Zhang et al. (2018) found that a wheat–maize system consistently outperformed single-season cropping, increasing annual grain production by 65-85% without significantly increasing inputs. The land equivalent ratio (LER) in these systems often exceeds 1.2, reflecting higher total productivity.

From a soil management perspective, double cropping contributes to improved soil structure, nutrient cycling, and organic matter buildup, especially when legumes are included in the sequence. Biological nitrogen fixation by legumes not only reduces the need for synthetic fertilizers but also enhances soil fertility in the long term (Álvaro-Fuentes et al., 2024). Moreover, keeping the land under vegetative cover for longer periods throughout the year helps prevent erosion and suppresses weed growth. Leguminous crops in double cropping contribute to biological nitrogen fixation, enhancing soil fertility (Fig. 2).

2. Water use efficiency

One of the critical constraints in arid regions is the availability and timing of water. Double cropping systems (DCS) are more water-intensive than monocultures; however, when properly managed, they can result in higher water productivity (Fig. 2). Studies conducted in dryland areas of China and India have

demonstrated that water productivity in double cropping systems can increase by 25-40% over traditional single-season systems, particularly under conservation agriculture practices (Gao et al., 2020). Furthermore, diversifying crop sequences through double cropping allows farmers to spread climatic risk, as different crops respond differently to heat, drought, and unpredictable precipitation (Gammans et al., 2025). **Gao et al. (2020)** provided a meta-analysis of double cropping systems in drylands across multiple countries. Their review concluded that DCS consistently increased WUE by 20-50% when compared to monoculture, and emphasized the role of integrated water and soil management practices (e.g., mulching, deficit irrigation, conservation agriculture). Research by Liang et al. (2022) also shows enhanced water use efficiency in DCS as a result of reduced water depletion in these systems.

3. Economic and livelihood impacts

Economically, double cropping enhances profitability by allowing farmers to harvest two crops instead of one, thus increasing total annual gross margins. Additionally, diversified cropping sequences reduce dependence on a single market or crop, thereby stabilizing income in years of price volatility. In rural dryland communities, where off-season employment opportunities are limited, double cropping provides continuous labor demand, contributing to household food security and rural employment (Waha et al., 2020). A study by Zhang et al. (2018) in northern Africa and western Asia revealed that double cropping increased annual net returns by 30-60% compared to single cropping systems under similar rainfall conditions, especially when paired with low-cost irrigation systems like drip or supplemental irrigation.

4. Environmental impacts and soil health

Double cropping, especially when combined with conservation agriculture practices, can improve **soil structure, organic matter content, and biodiversity**. A study by Lal (2007) demonstrated that systems with leguminous second crops enhance nitrogen fixation, reduce fertilizer needs, and mitigate greenhouse gas emissions.

Double cropping systems (DCS), characterized by the sequential cultivation of two crops on the same land within a single growing season, have demonstrated significant potential in improving key soil physical, chemical, and biological properties, particularly in intensively managed and resource-limited agroecosystems. One of the primary benefits of DCS is the enhancement of soil organic matter and carbon content due to the continuous biomass input from both crops, including root residues and above-ground litter (Lal, 2004). The increased plant cover and shorter fallow periods also contribute to reduced soil erosion and enhanced aggregate stability, especially on sloping or erosion-prone soils (Bationo et al., 2012). Furthermore, when legumes are integrated into double cropping systems significantly contribute to nitrogen enrichment through biological nitrogen fixation, improving soil fertility and reducing the need for synthetic fertilizers. DCS also supports enhanced microbial activity and soil biodiversity due to greater root exudates and diversified crop residues, which provide more diverse substrates for soil organisms (Tiemann et al., 2015). These microbial processes are closely linked to nutrient cycling, improved cation exchange capacity (CEC), and enhanced enzyme activity, all of which contribute to long-term soil health and productivity. Additionally, double

cropping systems with deep-rooted species can promote subsoil nutrient recycling and break hardpan layers, improving soil structure and water infiltration capacity (Rusinamhodzi et al., 2011). Importantly, several long-term field experiments have shown that DCS leads to more stable and resilient soil systems, even under climate-stressed conditions, by enhancing water retention and buffering capacity against temperature extremes. Collectively, these benefits underscore the role of DCS as a sustainable land management strategy that not only increases crop productivity but also contributes substantially to the restoration and maintenance of soil quality, especially in degraded or low-input farming systems.

5. Physical soil improvements

From a physical standpoint, double cropping contributes to improved soil structure and aggregation, largely due to continuous plant cover and root activity throughout the year. The presence of multiple crop root systems enhances soil porosity, bulk density, and infiltration rates, leading to better aeration and water-holding capacity (Rusinamhodzi et al., 2011; Lal, 2004). DCS also reduces the length of bare fallow periods, which helps mitigate soil erosion caused by wind and runoff, especially on vulnerable sloping lands (Bationo et al., 2012). Moreover, crop rotation and residue return from DCS can disrupt compacted layers (plow pans), enhancing root penetration and hydraulic conductivity.

6. Chemical soil improvements

In terms of chemical properties, DCS significantly improves soil organic carbon (SOC) and total nitrogen (N) due to greater biomass input from two cropping cycles per year (Fern´andez-Ortega et al., 2025). Studies have shown that integrating legumes into DCS increases available nitrogen through biological nitrogen fixation, reducing dependency on synthetic fertilizers and improving nitrogen-use efficiency. The enhanced cycling of nutrients in DCS systems also leads to higher cation exchange capacity and improved availability of phosphorus and micronutrients. In addition, the higher root turnover in such systems promotes pH buffering, and the inclusion of deep-rooted crops can enhance subsoil nutrient recycling.

7. Biological soil enhancement

Double cropping systems are strongly associated with improved soil biological properties. The increased plant diversity and year-round root activity stimulate microbial biomass, enzyme activity, and soil respiration, key indicators of a biologically active soil ecosystem (Tiemann et al., 2015). DCS enhances the diversity of soil microbial communities, including bacteria, fungi, and arbuscular mycorrhizal fungi (AMF), which play vital roles in nutrient cycling, soil aggregation, and disease suppression. Additionally, greater inputs of labile organic carbon through root exudates and residue decomposition in DCS improve microbial metabolic efficiency and soil food web complexity, leading to long-term ecological resilience.

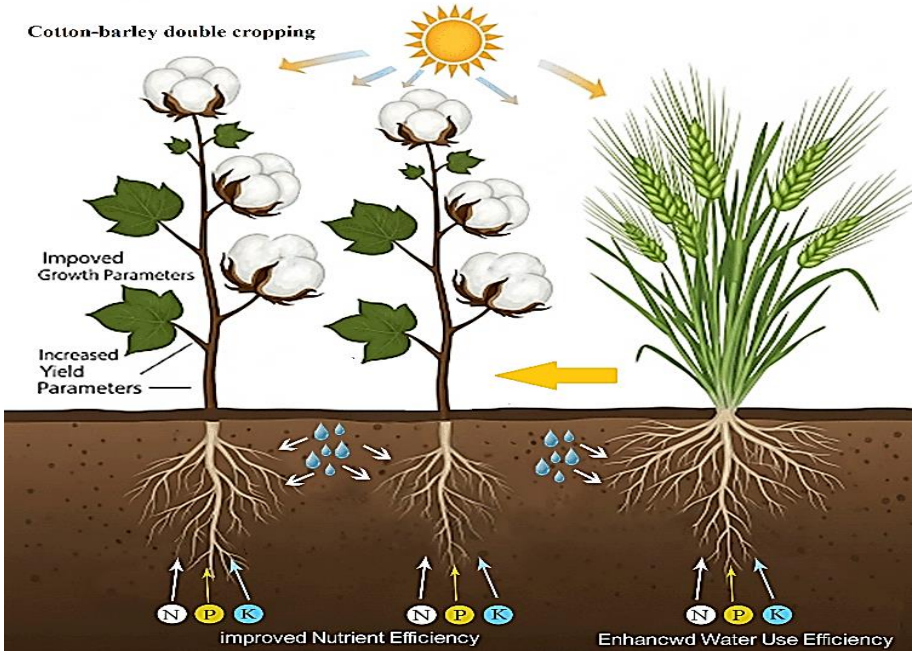


Figure 2. Conceptual image of growth, yield, water and nutrients use efficiency in cotton-barley double cropping system.

Challenges and constraints of double cropping in arid regions

1. Water limitation

One of the most critical barriers is the acute shortage of water. Double cropping demands reliable and sufficient water across two growing seasons, but in arid climates, rainfall is erratic and insufficient, while groundwater is often saline or over-extracted. Additionally, inefficient irrigation practices such as surface flooding lead to significant water losses, further reducing water-use efficiency.

2. Growing seasons and climate limitations

Arid regions often have short frost-free growing periods and extreme heat conditions, especially in summer. This restricts the selection of crop varieties and requires extremely fast-maturing cultivars. Delays in harvest or land preparation between cycles may overlap with climatic stress periods such as high temperatures or drought, compromising the viability of the second crop.

3. Soil fertility, salinity, and land degradation

Double cropping without proper soil fertility management leads to nutrient depletion, salinization, and soil structure degradation. Many dryland soils are already low in organic matter and suffer from secondary salinization due to poor drainage and excessive irrigation. Without the use of cover crops, composting, or rotation with legumes, long-term productivity declines significantly.

4. Access to inputs and appropriate technologies

Smallholder farmers in arid regions often lack timely access to critical inputs such as high-quality seeds, fertilizers, pesticides, and mechanized equipment. Moreover, technologies essential for

efficient double cropping, such as precision planting tools, water-saving irrigation (e.g., drip systems), and early-maturing crop varieties, are often either unaffordable or unavailable.

5. Labor, infrastructure, and economic risks

Double cropping intensifies demand for labor and infrastructure. In many rural areas, seasonal labor shortages or high labor costs during sowing and harvest seasons limit the practicality of a second crop. Inadequate rural infrastructure, particularly in storage, transport, and post-harvest handling, further limits market access and profitability. Without financial safety nets or crop insurance, farmers may avoid the additional risks of a second crop.

6. Policy and institutional constraints

Despite its potential, double cropping in drylands is rarely supported by policy or extension services. Most national agricultural policies are geared toward single-season cropping. Investment in adaptive research, training for dryland farmers, and subsidies for water-efficient technologies are often insufficient. A lack of integrated land and water management policies further complicates adoption.

Effects of double cropping on different properties of cotton and field crops

1. Growth characteristics

Double cropping systems (DCS), are increasingly recognized for their potential to enhance plant growth and development in farming systems. The improved growth performance of crops under DCS is attributed to multiple agroecological mechanisms, including better soil health, efficient use of resources, and favorable microclimatic conditions. One of the most significant effects of DCS on crop growth is the optimization of resource use efficiency, particularly light, water, and nutrients. When appropriately timed and spatially arranged, DCS ensures a continuous canopy cover that enhances photosynthetically active radiation (PAR) interception, thereby increasing photosynthesis and biomass accumulation in both early and late-season crops (Parihar et al., 2018). DCS also positively influences root development and nutrient uptake due to changes in rhizosphere dynamics and soil microbial activity. Studies have shown that crops grown in double cropping systems tend to exhibit enhanced root length density, deeper root penetration, and greater root biomass compared to monocropped systems (Wang et al., 2014; Giller et al., 2021). This improved root architecture facilitates better exploitation of nutrients, especially nitrogen and phosphorus, and improves plant vigor, resulting in faster establishment and more uniform crop stands (Sainju et al., 2017). Moreover, DCS has been linked to the modification of growth duration and phenological traits. For instance, second-season crops in DCS often adjust their reproductive stages to shorter day lengths or lower temperatures, depending on regional climatic conditions. These adaptive responses can enhance harvest index and yield stability, particularly in dryland agriculture or marginal environments (Corbeels et al., 2016). Additionally, these systems improve chlorophyll content, stomatal conductance, and transpiration efficiency, especially under limited water availability (Timsina & Connor, 2001). However, the

success of DCS in enhancing plant growth depends on crop compatibility, sowing time synchronization, and residue management. In an experiment, the growth traits of different cotton cultivars were investigated at various planting dates in a barley-cotton double cropping system. The results showed that early planting caused a decrease in all cotton growth traits, especially plant height, number of vegetative shoots, and number of reproductive shoots. In contrast, the percentage of earliness was lowest in plants planted at a later date (Seddighi et al., 2013).

2. Physiological traits

Double cropping systems, have shown promising effects on the physiological attributes of crops in various agroecological zones, especially in water-limited environments. Several recent studies have documented improvements in chlorophyll content, photosynthetic activity, growth rate, and developmental duration of crops under well-managed DCS compared to monocropping systems. A significant physiological response observed in DCS is the enhancement of chlorophyll content, which is directly linked to increased photosynthetic capacity and greater biomass production. The photosynthetic rate is often elevated under DCS, particularly when the preceding crop improves soil structure, nitrogen supply, or microclimatic conditions. This effect is more pronounced in dryland systems, where improved soil moisture retention under DCS supports sustained stomatal conductance and CO_2 fixation (Timsina & Connor, 2001). Another important physiological benefit is the increase in crop growth rate (CGR) and relative growth rate (RGR) due to synergistic effects of resource utilization and canopy dynamics. DCS can also lead to modifications in phenological development, extending or stabilizing the duration of both vegetative and reproductive phases. In terms of stress physiology, DCS has been shown to mitigate the negative impacts of abiotic stress by promoting osmotic adjustment, maintaining membrane stability, and enhancing antioxidant enzyme activity. It is important to note that these physiological advantages are not uniform and depend heavily on crop compatibility, soil fertility, residue management, and timing. Improperly designed DCS may result in suboptimal resource allocation or allelopathic effects that could diminish photosynthetic efficiency and slow down vegetative growth. Double cropping can significantly influence plant height, number of nodes, and leaf area index in cotton. Research indicates that when cotton is grown after legumes, residual nitrogen and improved soil structure contribute to increased vegetative growth.

Cotton cultivars are classified into three groups: early, middle and late mature (Bat, 1996). Early mature varieties *(Gossypium hirsutum*), known as upland cotton, divided into this category. Cotton cultivars are called early mature if their growing period does not exceed 140 days (Singh, 1998; Jenkins and Saha, 2001). Early mature varieties can be cultivated in colder regions because they can avoid the risk of early autumn low temperature in these regions. Also, these varieties will allow farmers to implement double cropping systems (Ramazani Moghadam, 2014).

The Khordad cotton variety is genetically early mature, and in dry areas

of the country, including South Khorasan and Razavi provinces, where the interference of the last water of the wheat and barley with the first water of the cotton delays the date of planting cotton, the date of planting this variety can be delayed until the end of June, and for this reason, its name Khordad (the persian name of June month) has been suggested. In other words, this variety can be used for double cropping systems. On the other hand, this early cotton variety can be a solution for areas with early autumn cold (Ramazani Moghaddam, 2014). The development of early mature varieties in Iran can prevent the area under cotton cultivation in the country from decreasing. In the past years, the existence of competing crops, especially those that had a shorter growth period than the existing commercial varieties of cotton, was one of the reasons for the decrease in the area under cotton cultivation in the country, and the introduction of early-maturing varieties of cotton as commercial varieties has been able to keep the area under cultivation stable to some extent. The Khordad variety was introduced as the first early mature variety in Iran in 2007 (Ramazani Moghaddam, 2014). It can be one of the main reasons for encouraging cotton farmers in the Boshrouyeh region of South Khorasan province to adopt conservation agriculture systems in cotton cultivation is the existence of the early mature variety of Khordad in this province.

3. Yield and yield components

Seddighi et al. (2013) evaluated the yield response of different cotton cultivars to various planting dates in a barley-cotton double cropping system. Combining the yield of the first and second crops as total yield revealed a significant difference among cultivars, with the Khordad cultivar showing the highest yield, followed by Varamin and Sepid cultivars, respectively. Additionally, plants planted after the last irrigation stage of barley exhibited the highest yield, while the lowest yield was recorded on the third planting date, after the barley harvest. Beyond improving total annual yield, DC systems can significantly influence the yield components of individual crops. A consistent trend reported across several studies is the increase in the number of productive tillers or branches. Similarly, 1000-grain weight, a key determinant of final yield, is often maintained or slightly increased under double cropping systems, particularly when planting dates and water management are optimized. Harvest index (HI), the ratio of economic yield to total biomass, is another parameter frequently reported to improve under well-managed DCS (Feng et al., 2017). This is attributed to more balanced allocation of assimilates towards reproductive organs, facilitated by synchronized phenology and favorable source-sink dynamics. In most studies, the number of fruiting branches and bolls per plant increases under DCS when cotton follows short-duration legumes due to improved soil fertility and early canopy establishment (Seddighi et al., 2013). Wang et al. (2020) also stated in their research that biomass production and crop yield in the cotton-wheat double cropping system increase due to improved resource use efficiency.

In a study by Seddighi et al.2013 in Gonabad arid region (very closed to dessert) at the south of Razavi Khorasan province, showed that the early-mature Khordad variety can have acceptable and economic performance even when planted late after barley (Fig. 3).

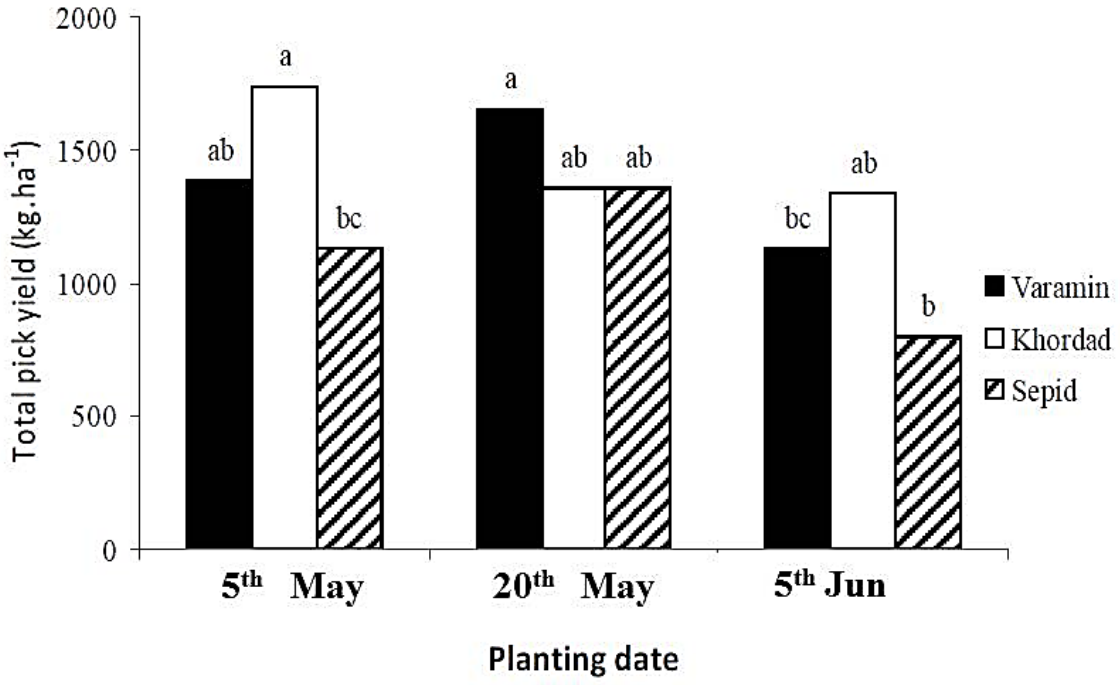


Figure 3. Interaction effect between planting date and cultivar on total pick yield. Seddighi et al. (2013).

4. Fiber quality

Fiber length and strength are particularly sensitive to the duration of the elongation and thickening phases, which are influenced by heat units, water availability, and light interception-parameters often compromised in double-cropping systems. Double-cropping maximizes land productivity but often delays cotton sowing due to the preceding crop's growth period. This delayed planting exposes cotton to late-season heat and drought stress during key fiber development phases, which can adversely affect fiber quality. In an experiment conducted on barley-cotton double cropping, researchers found that cotton plants planted late, after wheat harvest, exhibited greater fiber length (Seddighi et al., 2012). Delayed planting is the most direct consequence of double-cropping. A research shows that late-planted cotton experiences compressed growth and fiber development stages, which may reduce fiber length and strength (Seddighi et al., 2012). In particular, shortened boll maturation periods can lead to immature fibers, negatively affecting micronaire and increasing variability in fiber quality.

Fiber length is highly sensitive to the duration and conditions of the elongation phase. Cotton in double-cropped systems, particularly when sown late, often experiences compressed boll development. Fiber length depends on both genotype and environmental conditions. Cotton grown in double-cropped systems often produces shorter fibers due to thermal stress during boll development and insufficient vegetative growth (Pettigrew, 2004). Moreover, limited canopy development can reduce assimilate partitioning to developing bolls, leading to suboptimal fiber elongation. Studies show that cotton sowed after legumes generally maintains or slightly improves fiber length compared

to monoculture systems, due to enhanced nitrogen availability (Pettigrew, 2004). Cotton following maize or sorghum may sometimes experience slightly reduced fiber length due to higher residue and slower N mineralization. Similarly, trials in Iran also showed slightly increased fiber length under delayed planting, though differences were cultivar-dependent (Seddighi et al., 2012).

Micronaire is a composite measure of fiber maturity and fineness. In double cropping systems, cotton often fails to reach full fiber maturity due to shortened boll filling periods. This leads to lower micronaire index and more immature fibers. While lower micronaire may be acceptable in some spinning systems, extreme reductions reduce processing efficiency. Double cropping systems can alter boll development timing and uniformity, especially under conservation tillage. In double-cropping systems, cotton often fails to reach full fiber maturity due to shortened boll filling periods. This leads to lower micronaire index and more immature fibers. While lower micronaire may be acceptable in some spinning systems, extreme reductions reduce processing efficiency. Some researchers have pointed to a decrease in the micronaire index of cotton fibers due to a delay in the planting date, often attributing these results to the effect of ambient temperature on the boll formation process and cotton fiber growth. During an experiment examining the response of different cotton cultivars to a barley-based double cropping system, it was found that the quality of cotton fibers varied among cultivars. Moreover, early planting reduced micronaire index, whereas the second planting date, coinciding with the end of barley irrigation, resulted in the best micronaire index (Seddighi et al., 2012).

Cotton fiber strength is influenced by the duration and rate of secondary wall thickening. High night temperatures and water stress, more likely in late-season crops, can interfere with cellulose deposition, resulting in weaker fibers. Studies have reported a decline in fiber strength in cotton grown in wheat-cotton systems compared to mono cropped cotton. Research shows that late-sown cotton in wheat-cotton systems had lower strength values compared to early-sown cotton (Awan et al., 2014). Researchers stated that cotton in legume-based rotations benefits from improved N availability, while cotton following cover crops shows better water retention and reduced thermal stress that contribute to improved strength. Pettigrew (2016) reported similar fiber strength across continuous cotton and rotated cotton, but under low-stress years, the rotated plots showed slightly higher values. Seddighi et al. (2012) conducted a study on barley-cotton intercropping in an arid region and concluded that delaying cotton planting until after wheat harvest resulted in cotton fibers with higher elongation and greater strength. The impact of delayed sowing on fiber strength is less consistent.

Lint percentage may decline in double-cropping systems due to smaller boll size and poor boll retention under heat or drought stress. Delayed planting can reduce boll numbers and fiber biomass per boll, thus affecting total lint yield and the proportion of lint to seed. However, appropriate variety selection and management practices can partially mitigate these effects. Double-cropping

systems may reduce lint percentage due to smaller boll size and lower boll retention under heat stress. However, appropriate genotype selection and stress mitigation strategies (e.g., irrigation, plant growth regulators) can help maintain acceptable lint percentages. Delayed sowing frequently reduces lint percentage and total yield due to a shortened boll-filling period and increased risk of frost or early defoliation. Similarly, a study on the effect of different planting dates in a barley-cotton double cropping system found that plants planted late, after barley harvest, had a higher lint percentage than those planted earlier (Seddighi et al., 2012).

The need to transition from mono-cropping to double cropping systems in sustainable agriculture

The transition from conventional monocropping systems to more intensive and diversified cropping strategies such as double cropping is increasingly recognized as a necessary step toward enhancing food security, optimizing resource use, and improving system resilience, particularly under the constraints imposed by climate change and land scarcity. Conventional monoculture systems often lead to negative environmental consequences, including soil degradation, pest and disease buildup, declining biodiversity, and inefficient use of water and nutrients. In contrast, double cropping offers the potential to significantly increase total annual productivity, improve land-use efficiency, and enhance farmers' income, without requiring additional land expansion. Moreover, double cropping systems have shown to improve soil fertility and reduce weed pressure when leguminous or cover crops are integrated into the rotation. The practice also contributes to more stable yields in the face of erratic weather patterns by distributing risk across multiple cropping periods. With global food demand projected to rise by 60% by 2050 and arable land per capita continuing to decline, there is an urgent need for sustainable intensification strategies that can produce more output per unit of land and water (FAO, 2017). Particularly in water-limited environments, such as arid and semi-arid regions, double cropping using drought-tolerant and early-maturing varieties, coupled with conservation agriculture practices, can lead to improved water productivity and system resilience. The shift toward double cropping systems is thus not only agronomically viable but strategically essential for ensuring the sustainability of global agriculture in the face of ecological and socio-economic challenges.

Today, with the introduction of early-maturing varieties and conservation agriculture methods integrated with in the arid regions of Iran, especially in areas under salinity stress, the cotton-barley double cropping system has been able to provide good economic benefits in addition to agronomic advantages for farmers (Fig 4 and 5).



Figure 4. Varamin cultivar in a No-tillage (conservation agriculture) cropping system after barley. Esfaraien, North Khorasan Province, (Photo by M.R. Ramazani Moghaddam July 2025).



Figure 5. Khorshid a zero-branch and early mature variety in a No-tillage (conservation agriculture) and Ultra Narrow Rows Planting system after barley. Esfaraien, North Khorasan Province, (Photo by M.R. Ramazani Moghaddam July 2025).

The future of double cropping systems (DCS) in arid regions

The future of double cropping systems (DCS) in arid regions is poised for significant evolution, driven by mounting challenges related to climate change, water scarcity, land degradation, and the urgent need to enhance food security under resource-limited conditions. As these regions face increasing climatic instability, characterized by prolonged droughts, erratic rainfall patterns, and rising temperatures, DCS will likely emerge not only as an intensification strategy but also as a resilience-building approach in dryland agriculture. In the coming decades, the integration of drought-tolerant and early-maturing crop varieties, supported by advanced breeding programs and biotechnology, will become increasingly essential. This genetic

innovation will enable the cultivation of two crops within a single year while minimizing risk and ensuring optimal resource use. Moreover, future DCS will be closely tied to technological advancements in precision agriculture, including real-time monitoring of soil moisture, smart irrigation systems, and digital decision-support tools that help farmers optimize planting schedules and input use. Water productivity will be a central pillar of future strategies, encouraging the adoption of subsurface drip irrigation, deficit irrigation, and the use of non-conventional water sources such as treated wastewater, especially in peri-urban zones. In addition, soil health management will receive greater attention through the inclusion of cover crops, crop residue retention, and organic amendments, reinforcing the long-term sustainability of intensively cropped systems. The trend toward regenerative and circular agricultural practices is expected to intersect with DCS through the incorporation of crop-livestock interactions and agroforestry models, which not only diversify income sources but also enhance ecological resilience. On the institutional level, supportive policies and inclusive innovation ecosystems will be vital for enabling widespread adoption of double cropping, particularly in marginalized rural communities. Investments in research and extension services, along with incentives for adopting water-saving and climate-smart cropping patterns, will help scale effective models across diverse agro-ecological zones. Furthermore, participatory research involving farmers, scientists, and development stakeholders will play a critical role in adapting DCS to local socio-economic and environmental contexts. Overall, the future of double cropping in drylands will depend on synergizing agronomic innovation with policy support, environmental stewardship, and community engagement. If these elements align effectively, double cropping systems can contribute meaningfully to the dual goals of enhancing productivity and building climate-resilient food systems in some of the world's most vulnerable landscapes.

Conclusion and future perspective

Double cropping stands as one of the most promising and necessary strategies to address the growing challenges of food security, land degradation, and climate variability, especially in dry and semi-arid regions. By allowing two harvests within a single agricultural year, double cropping systems make far more efficient use of land, water, and sunlight than traditional monocropping. These systems not only increase total productivity per hectare, but also contribute to improved soil health, optimized nutrient cycling, better pest and weed control, and enhanced economic stability for farmers. In regions where water scarcity and shortened growing seasons limit agricultural options, double cropping enables farmers to diversify production and take full advantage of favorable climatic windows. Crop combinations that include legumes can enhance soil fertility through biological nitrogen fixation, while staggered planting and harvesting schedules help manage labor more effectively. Over time, the consistent return of organic residues to the soil and the reduced need for chemical inputs promote long-term sustainability of farming systems in these challenging

environments. Physiologically, crops grown under well-managed double cropping regimes often benefit from improved growth parameters, including increased chlorophyll content, higher rates of photosynthesis, and extended vegetative and reproductive phases. These effects translate into improved yield components such as greater biomass accumulation, more fruits or grains per plant, and increased harvest index. Moreover, the enhanced use of residual soil moisture and nutrients between two cropping cycles maximizes resource-use efficiency and reduces environmental losses. From an economic standpoint, double cropping can significantly raise annual income for smallholder and commercial farmers alike, as it allows better land utilization and higher annual output without requiring the expansion of cultivated areas. This system can serve as a buffer against market fluctuations or crop failures, providing more flexibility in crop marketing and food supply planning. Despite its many benefits, the implementation of double cropping is not without challenges. Infrastructural limitations, lack of access to timely irrigation, labor constraints, and the need for crop varieties with shorter maturity cycles remain key barriers in many dryland areas. However, with appropriate planning, farmer education, investment in irrigation technology, and supportive agricultural policy, these challenges can be overcome. Looking forward, the expansion of double cropping systems should be considered a strategic priority for sustainable agricultural intensification in water-limited regions. There is a need for greater integration of local knowledge with modern agronomic practices, along with targeted research into crop combinations that are both ecologically compatible and economically viable. Capacity building among farmers, improved extension services, and development of resilient seed systems will also be critical to success. Ultimately, double cropping offers a pathway not only to higher agricultural productivity but also to enhanced environmental stewardship, rural development, and resilience to climate change. It represents a practical and scalable solution for the sustainable transformation of agriculture in drylands, and its broader adoption will play an essential role in shaping the future of food systems in many vulnerable regions of the world.

References

Álvaro-Fuentes, J., López-García, A., & Plaza-Bonilla, D. (2024). Impact on crop productivity and nitrogen dynamics under double-cropping systems with legumes in semiarid Mediterranean conditions. Journal of Agricultural and Food Research, 15, 100868

Basche, A. D., & de Ramirèz, F. V. (2020). Cover crops improve soil health and enhance agricultural resilience in the Corn Belt. Frontiers in Sustainable Food Systems, 4, 584993

Bationo, A., Waswa, B., Kihara, J., & Kimetu, J. (2012). Innovations as key to the green revolution in Africa: Exploring the scientific facts. Springer.

Corbeels, M., de Graaff, J., and Ndah, T.H. (2016). Understanding the impact and adoption of conservation agriculture in Africa. Agriculture,

Ecosystems & Environment, 222, 213-225.

FAO. (2017). The future of food and agriculture: Trends and challenges. Rome: Food and Agriculture Organization of the United Nations.

Feng, L., Wang, G., Han, Y., Li, Y., Zhu, Y., Zhou, Z., & Cao, W. (2017). Effects of planting pattern on growth and yield and economic benefits of cotton in a wheat-cotton double cropping system versus monoculture cotton. Field Crops Research, 213, 100-108.

Fern´andez-Ortega, J., Alvaro-Fuentes, J., Delgado, A., García-L´opez, A. M., & Cantero-Martínez, C. (2025). Assessing management strategies for carbon storage in Mediterranean soils: Double-cropping, no-tillage, and nitrogen fertilization reduction. Soil & Tillage Research, 249, 106496.

Gammans, M., Mérel, P., & Ortiz-Bobea, A. (2025). Double cropping as an adaptation to climate change in the United States. American Journal of Agricultural Economics, 107(2), 532-557.

Gao, Y., Duan, A., Qiu, X, Sun, J., Liu, Z., Wang, H., & Zhao, C. 2020. Water use efficiency and yield performance of intercropping and double cropping systems in arid regions. Field Crops Research, 255, 107865.

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2021). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 261, 108038.

Jemberu, M. A., Bizuayehu, T. A., & Gebrehiwot, H. H. (2021). The adoption impact of wheat-chickpea double cropping on yield and farm income of smallholder farmers in Central Highlands of Ethiopia: The case of Becho district. Heliyon, 7(6), e07379

Kar, G., Kumar, A., & Singh, R. (2012). Long-term effects of conservation tillage and crop rotation on soil properties and crop productivity in a dryland region of India. Soil & Tillage Research, 124, 77-85.

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. Geoderma, 123(1-2), 1-22.

Lal, R. (2007). Soil carbon sequestration and conservation agriculture. Journal of Soil and Water Conservation, 62(3), 113-120.

Liang, Z., van der Werf, W., Xu, Z., Cheng, J., Wang, C., Cong, W. F., Zhang, C., Zhang, F., & Groot, J. C. J. (2022). Identifying exemplary sustainable cropping systems using a positive evidence approach: Wheat-maize double cropping in the North China Plain. Agricultural Systems, 201, 103471.

Parihar, C. M., Yadav, M. R., Jat, S. L., Singh, A. K., Kumar, B., Pooniya, V., Pradhan, S., Verma, R. K., Jat, M. L., Jat, R. K., Parihar, M. D., Nayak, H. S., & Saharawat, Y. S. (2022). Long-term conservation agriculture and intensified cropping systems: Effects on growth, yield, water, and energy-use efficiency of maize in northwestern India. Pedosphere, 28(6), 952-963.

Pettigrew, W. T. (2004). Physiological consequences of early-season and late-season plantings on cotton fiber quality. Crop Science, 44(3), 893-901.

Pettigrew, W. T. (2016). Growth and agronomic performance of cotton grown in rotation with soybean. Journal of Cotton Science, 20(4), 299-308.

Ramazani Moghaddam, M.R. 2014. Introduction of Khordad, new cultivar of cotton. *The final report of project. Cotton Research Institute of Iran Publicatin.* 35 pp.

Rana, D. S., & Kukal, S. S. (2019). Multiple cropping systems: A strategy for sustainable food security. Agriculture & Food Security, 8(1), 1-7.

Ray, D. K., West, P. C., Clark, M., Gerber, J. S., Prishchepov, A. V., & Smith, W. K. (2020). Multiple cropping systems of the world and the potential for increasing cropping intensity. Global Food Security, 26, 100416.

Rockström, J., Falkenmark, M., Lannerstad, M., Karlberg, L. (2014). Water resilience for human prosperity. Cambridge University Press.

Rusinamhodzi, L., Corbeels, M., van Wijk, M. T., Rufino, M. C., Nyamangara, J., & Giller, K. E. (2011). A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. Agronomy for Sustainable Development, 31(4), 657-673.

Sainju, U. M., Jabro, J. D., & Stevens, W. B. (2017). Soil carbon and nitrogen changes with reduced tillage, crop rotation, and cover cropping. Soil Science Society of America Journal, 81(3), 966-982.

Seddighi, E., Ramazani Moghadam, M. R., Sirousmehr, A. R. and Asgharipour, M. R. 2013. Investigation on the effect of cotton cultivars and different planting dates on barley-cotton double cropping system in Gonabad climatic conditions. Journal of Agroecology, 5(1): 58-66.

Seddighi, E., Sirousmehr, A. R., Ramazani Moghadam, M. R., Asgharipour, M. R. and Esmaeilian, Y. 2012. Investigation the yield and qualitative traits of cotton under different planting dates in barley-cotton double cropping system. Journal of Plant Environmental physiology, 6(4): 26-36.

Smith, P., Soussana, J. F., Angers, D., Schiper, L., Chenu, C., Rasse, D. P., Batjes, N. H., van Egmond, F., McNeill, S., Kuhnert, M., Arias-Navarro, C., Olesen, J. E., Chirinda, N., Fornara, D., Wollenberg, E., Álvaro-Fuentes, J., Sanz-Cobena, A., & Klumpp, K. (2020). How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. Global Change Biology, 26(1), 219-241.

Stevenson, J. R., et al. (2013). Assessing the productivity of cropping systems in developing countries. Nature Communications, 4, 2514.

Tadesse, M., & Mengistu, D. (2021). The adoption impact of wheat-chickpea double cropping on yield and farm income of smallholder farmers in Central Highlands of Ethiopia: the case of Becho district. Heliyon, 7(6), e07379.

Tiemann, L. K., Grandy, A. S., Atkinson, E. E., Marin-Spiotta, E., & McDaniel, M. D. (2015). Crop rotational diversity enhances belowground communities and functions. Ecology Letters, 18(8), 761-771.

Timsina, J., & Connor, D.J. (2001). Productivity and management of rice-wheat cropping systems: Issues and challenges. Field Crops Research, 69(2), 93-132.

Waha, K., Van Bussel, L. G. J., Müller, C., Rolinski, S., & Heinke, J. (2020). Multiple cropping systems of the world and the potential for increasing cropping intensity. Global Food Security, 26, 100416.

Wang, J., Li, Y., & Zhang, L. (2014). Root development and grain yield of wheat in wheat-maize double cropping system. Agricultural Sciences in China, 13(8), 1062-1071.

Wang, G., Li, Y., Han, Y., Wang, Z., Yang, B., Li, X & Feng, L. (2020). Resource use efficiency in a cotton-wheat double-cropping system in the Yellow River Valley of China. Experimental Agriculture, 56, 422-439.

Zhang, H., Van der Werf, W., Zhang, L., & Li, L. (2018). Yields and interspecific interactions in cereal/legume intercropping systems: A meta-analysis. Field Crops Research, 222, 147-157.

REGISTRATION OF NEW COTTON CULTIVARS SYSTEM AND PROCESS IN IRAN, AN OVERVIEW

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Abstract

New improved varieties of crops with improved yields, higher quality or better resistance to pests and diseases increase quality and productivity in agriculture, horticulture and forestry, while minimizing the pressure on the environment. Accessibility to the improved plant varieties is vital for agricultural and horticultural industries. Cotton breeding in Iran has focused on improving fiber yield, boll weight, and early maturity. Plant variety registration is a way for breeders to protect the new plant varieties they make. Until 2003 Iran lacking any seed law and the Act of Plant Varieties Registration, Control and Certification of Seeds and Plant Materials of Islamic Republic of Iran Act was in approved in parliament. Plant variety rights (PVRs) came into operation in Iran during 2011 under the provision of the bylaw on plant variety protection of the act on plant variety protection and seed certification**.** The plants new varieties registration and introduction process in Iran conduction based on UPOV guidelines for Distinctness, Uniformity, and Stability (DUS) trial**.** During 2010 to 2023 by conducting Distinctness, Uniformity, and Stability (DUS) trials 96 common and new cotton cultivars and genotypes Distinctness, Uniformity, and Stability evaluated and many commercial cultivars registered in Iran.

Key words: Variety, Distinctness, Uniformity, Stability, Registration.

Introduction

The world population is increasing and arable land and other environmental resources are becoming more limited day by day. Therefore, the preparation of improved varieties that are high-yielding and resistant to diseases and environmental stresses has positive economic and

environmental effects. There is no doubt that in the 21st century, new agricultural and horticultural varieties that have excellent economic and marketing value will be offered in global markets (Monostoei, 2014).

Cotton is a multi-purpose plant: from clothing to oil production, from papermaking to the chemical industry, just to name a few areas where man has historically used this fundamental input, as the infographic below shows (Ahmad and Hasanuzzaman, 2020). Also, Cotton is one of the most important industrial crops in Iran (Hamidi *et al*., 2012). During 2021-2022 crop year cotton fields harvested area was 118473 hectares, produced seed cotton amount was 374444 tons and 3198 and 1785 kg/ha respectively irrigated and rain fed seed cotton yield in Iran (Jihade-e-Agriculture Ministry, 2024).

New improved varieties of crops with improved yields, higher quality or better resistance to pests and diseases increase quality and productivity in agriculture, horticulture and forestry, while minimizing the pressure on the environment (Sadeghian Motahar, 2008).

Plant breeding is a discipline focused on improving plants for various purposes, primarily for food production and other human needs, through genetic manipulation. It involves selecting plants with desirable traits and breeding them to enhance characteristics like yield, disease resistance, and nutritional content. This process has evolved from an art practiced by farmers to a science utilizing advanced techniques like genetics and molecular biology. Plant breeding begins with the discovery or creation of new genetic changes in plant species. Among the resulting genetic changes, the selection of plants with high yield, resistance to biotic and abiotic stresses, desirable color in ornamental plants, and uniformity in the form and shape of fruit trees and ornamental plants are priorities in breeding research. The breeder may use different techniques or forms of technology to create genetic changes. However, creating the changes desired by the breeder in plant populations and selecting the desired plants is the first and most important step in selecting superior genotypes (Sadeghian Motahar, 2008).

Plant breeding is a very long process, and plant material is examined and evaluated in different generations under different conditions in the field, laboratory, and greenhouse, and different techniques are used to identify superior genotypes in the laboratory and field. Therefore, not only advanced knowledge and techniques, but also a lot of money is spent on preparing a modified variety over many years. As a result, material and moral support for modified varieties by governments is necessary and inevitable. The world's population is increasing, and agricultural land and other environmental resources are becoming more limited day by day. Therefore, preparing high-yielding modified varieties that are resistant to diseases and environmental stresses has positive economic and environmental effects. There is no doubt that in the 21st century, new agricultural and horticultural varieties that have excellent economic and marketing value will be offered in global markets. Plant breeding is the continuous endeavor to develop superior plant phenotypes that are better adapted to human needs by utilizing the available

genetic variation. It has been practiced for thousands of years ever since the beginning of human civilization, initially as an art by the farmers and later as a science by breeders. The aim of plant breeding is to improve the quality, diversity, and performance of food, fiber, forage, industrial, and other economically important crops. Crop breeding is a rapidly advancing science and has made use of recent genetic and biotechnological innovations to efficiently develop better crop varieties (Acquaah, 2012).

Plant breeding in Iran is an active field, with both traditional and modern techniques being employed to enhance crop production. Research focuses on developing new varieties with improved traits like disease resistance, yield, and climate resilience (Farsi and Bagheri, 2023).

Agricultural Research, Education and Extension Organization (AREEO) are the largest responsible body for agricultural research, education and extension in ministry of Jihad–e-Agriculture of Iran. New plants breeding are one of major duties of Agricultural Research, Education and Extension Organization (AREEO). During 1936-1959, Varamin Plant Breeding Corporation was the only responsible body for cotton research in Iran. After the establishment of Seed and Plant Improvement Institute (SPII) in 1959, the research activities on cotton were moved under the management of SPII in the Cotton Research Department. Regarding the national importance of cotton in textile and oil industries, in 1997, the Cotton Research Institute of Iran (CRII) was established in the Northern region of Iran, Gorgan, coordinates basic and applied researches along with the development activities on cotton in order to enhance the productivity and profitability of cotton farmers and the added value chain associated with cotton. CRII has closely cooperated with other institutes in research, farming, industry, and technology. Main responsibilities of the CRII includes: development of high yielding varieties, good quality fiber, disease and pest resistant varieties for various regions of Iran, improvement of seed quality and formulate the production technology for cotton under different changing climates. Important cotton research topics in Iran are: 1-Cotton varieties improvement, 2-Abiotic stresses (drought and salinity), 3- Enhancing water use efficiency, 4- Pest and diseases resistance, 5- Cotton yield and quality improvement, 6- Agronomical, physiological and ecological studies in cotton plants and 7- Integrated pest management (IPM) strategies(Alishah, 2013).

There are five research departments in CRII headquarters located in Gorgan, namely; Breeding, Agronomy, Plant Protection, Agricultural Engineering and Research Technical Services in Gorgan. It has one research department in Varamin and 14 research stations in the different cotton production areas of Iran. Cotton Research Institute of Iran is responsible for providing all research priorities and activities at the national level. Main station of CRII is Hashemabad Cotton Research Station for breeding research and for studying of cultivar resistant to Verticillium wilt, other disease and pests is Karkandeh Cotton Research Station.

Missions of the **Cotton Research Institute of Iran (CRII) including: 1**-Developing cotton research towards the introduction of improved cultivars suitable for different environmental conditions throughout the country, 2-Development of appropriate farming/cropping system for different cotton growing zones and their effective management, 3-Conserving Cotton germplasm, 4-Development of effective and efficient disease, pest and weed management strategies, 5- The direction of researches in cotton breeding, agronomy, biotechnology and seed technology, 6-Development and production of cotton seed nucleus, 7-Providing training courses and workshops in cotton production and also transferring of research findings to extension agencies, experts and farmers by the cooperation of extension and education services(Hamidi *et al*., 2012).

Cotton breeding in Iran has focused on improving fiber yield, boll weight, and early maturity. Research has explored genetic diversity among landraces and the impact of different breeding strategies. Studies have also evaluated the economic benefits of cotton research and the effects of plant density on yield components (Alishah, 2013).

Key aspects of cotton breeding in Iran Focus on seed cotton yield and fiber quality, genetic diversity, impact of plant density and economic benefits. Cotton breeding programs in Iran is aim to enhance fiber yield, boll weight, and early maturity, crucial for competitiveness and profitability. Also research explores genetic diversity within Iranian cotton landraces to identify superior traits for breeding, studies investigate the effects of varying plant densities on yield and yield components, with some research suggesting optimal densities for specific cultivars, research on the economic impact of cotton breeding highlights the potential for increased production and benefits to growers and consumers are the main key aspects of cotton breeding in Iran (Yazdi Samadi and Abd Mishani, 1997).

For cultivar evaluation purposes studies evaluate the performance of different cotton cultivars, including imported and hybrid varieties, under various conditions. Cotton breeding strategies in Iran includes research explores different breeding strategies, such as selection based on specific traits (e.g., boll weight, early maturity) and crossing strategies to combine desirable traits. Cotton breeding role of research in Iran is important because the research plays a vital role in enhancing the competitiveness of cotton production and identifying strategies to improve yield and quality (Barzali, 2020).

A study compared the productivity of old and new cotton cultivars, showing a significant increase in fiber yield with advanced genotypes, research on plant density in cotton investigated the effects of reduced row spacing on yield and yield components in different locations, analysis of genetic diversity in cotton landraces identified traits like boll weight as key factors influencing yield and an evaluation of the economic effects of cotton research in Razavi Khorasan province assessed the potential benefits of breeding programs are the major examples of cotton research (Hamidi *et al*., 2012).

Major achievements of CRII are:

1- Releasing of 14 cotton cultivars during recent years including Sepid, Khordad, Golestan, Armaghan, Khorshid, Kashmar,

Latif, Shayan, Sajedi, Hekmat, Partov, Taban, Fakhr and Jahesh, 2- Identification of bio-ecology of cotton pests and diseases, 3- Monitoring and controlling of quarantined pests and diseases, 4- Increasing of cotton water productivity by optimizing of irrigation methods, 5- Preparation of digital soil fertility maps for all Golestan agricultural service centers, 6- Projecting of semi- mechanized machine of cotton harvester for small farms, 7- Feasibility of cotton transplanting in Iran, 8- Development of cotton based on conservation agriculture in Iran, 9- Enhancement of cotton germplasm collection from 190 to more than 450 germplasms and lines, 10- Nucleus seed production for at least 14 cotton cultivars at different stations and 11- Using peaceful nuclear energy to produce two mutant varieties: 1-Taban, 2-Partov, 3-Fakhr and 4-Jahesh(https://cri.areeo.ac.ir/).

Accessibility to the improved plant varieties is vital for agricultural and horticultural industries. Providing food-security for growing population of the world, sustainable agricultural production, need for an increase in agricultural incomes, economic development and improvement are necessary for sustainable efforts in the field of plant breeding and improving (Evenson and Gollin, 2003). Considering the specific and complex processes, expensive and long lasting plant breeding and reproducibility and easy access to the plants' materials of new varieties, efforts in this area will be justifiable and imaginable so that there will be an opportunity for returning the investment. Granting exclusive right to breeders (breeders' rights) and those who are in charge is assumed to be an effective factor in enhancing investigator's motivation; particularly investing in private sectors. In the realm of competition and free trade and commerce (free market), protection of the new plant varieties, as one of new realms of intellectual property rights has been referred to as the Patent or an effective Sui-Generis system or a combination of both these systems. In line with operation of the scientific efficiencies and competencies existing in this international field, and facilitation of access to new technology of protection of these varieties in Iranian laws, a new area has been assigned as sui-generis system (special protective system). The current essay tries to indicate and explain this special system with a special emphasis on standards on International Union for the Protection of New Varieties of Plants (UPOV) (Habiba and Heidari, 2014).

Until 2003 Iran lacking any seed law and the Act of Plant Varieties Registration, Control and Certification of Seeds and Plant Materials of Islamic Republic of Iran Act was in approved in parliament in 2003 and according to this Act and for the purpose of safeguarding national interests and organizing the process of controlling and certifying seeds and plant materials and for protection of breeders' intellectual properties, the Ministry of Jihad-e-Agriculture shall be responsible to identify and register the newly produced plant varieties and take actions to control and monitor the affairs related to the country`s seed and plant material (Mozafari *et al*., 2010).

According to Control and Certification of Seeds and Plant Materials of Islamic Republic of Iran Act Article 1 of the Plant Varieties Registration and Seed and Plant

Control and Certification Law, the Ministry of Agricultural Jihad is required to identify and register new plant varieties and control and supervise the country's seed and seedling affairs in order to protect national interests, organize the control and certification of seeds and seedlings, and protect the intellectual property rights of breeders. Also according to the Act second article, for the implementation of the provisions of this Act, the Seed and Plant Certification and Registration Institute, SPCRI, established within the Agricultural Research Extension and Education Organization (AREEO) in the Ministry of Jihad-e-Agriculture. The institute exclusively carry out all nations wide activities related to the identification and registration of plant varieties and control and certification of seeds and plant materials The Act third article explained, in case the new plant varieties fully comply with the following conditions and requirements are eligible to be registered: 1. The new cultivars should have distinct genetic characteristics and features as compared to previously registered or identified cultivars. The transgenic varieties shall be subject to the provisions of this Clause, 2.The new varieties shall be identical from genetic, and morphological aspects or both, and 3. The specification of the variety, whether a hybrid or non-hybrid one shall remain unchanged during the years of production and propagation (Seed and Plant Certification and Registration Institute, 2019).

Plant variety rights (PVRs) came into operation in Iran during 2011 under the provision of the bylaw on plant variety protection of the act on plant variety protection and seed certification (2003).

To protect the ownership of a variety, breeders (Legal entities or natural persons), who have the Iranian nationality, can apply for the Plant Breeders' Rights for the variety. It is possible to apply for Plant Breeders' Rights for varieties of some limited genera and species.

A grant of plant variety rights may be made if the variety is:

- **New**, meaning not sold in Iran for more than 12 months, and overseas for more than four or six years (depending on the type of plant).
- **Distinct**, meaning distinguishable from any other known variety by one or more (morphological or physiological) characteristics.
- **Uniform,** meaning that there is little difference between all the plants of a particular generation.
- **Stable,** meaning that successive generations retain the characteristics of the original variety.
- Has an acceptable denomination, and Formalities are met.

If a new variety complies with DUS criteria and has been given an accepted name, the Plant Breeders' Right will be granted. The breeder’s right shall be granted for a fixed period of 18 years for all type of plants (Mozafari *et al*., 2010).

Plant variety registration is a way for breeders to protect the new plant varieties they make. When a plant variety has never been grown, sold, or shown to the public before, it is called "new." When a breeder registers a new variety, they legally own it. This means that for a certain amount of time, only the breeder can grow, sell, or give away that specific plant variety. It helps parents keep other people from

copying their work. Descriptors of varieties of crop species are required for characterization of varietal identity, determine varietal purity and establish the distinctiveness of new variety from existing varieties and documentation of genetic resources. It means that the new variety has to be Distinct-Uniform-Stable (DUS) in its characteristics. Distinct means, a variety should be clearly distinguishable by one or more essential characteristics from any other existing variety. The variety is deemed uniform, if it is sufficiently uniform in its relevant characteristics, subject to variation that may be expected from the particular features of its population. The variety is said to be stable, if its relevant characteristics remain unchanged after repeated propagation. Characterization of any variety or hybrid is must to know its novelty for the registration and notification (Mozafari *et al*., 2010).

According to Article 5 of the Plant Variety Registration Regulations, the registration process is summarized as follows: 1- Completing and submitting the registration application in two copies along with the technical questionnaire and the completed research memorandum to the Legal Protection Management, 2- Paying the registration application review fee (registration and commercialization fees, 3-Reviewing the information contained in the application by the Intellectual Property Office, 4-Delivering the second copy of the approved application with the number, date, and stamp of the Legal Office to the applicant, 5- Paying the cost of conducting the Distinction, Uniformity, and Stability (DUS) test, 6-Delivering the seeds required for the type test (DUS) based on the amount stated in the seed submission conditions guide, 7-Publishing the application for variety registration in the official newspaper of the country and the Institute's publication at the applicant's expense and 8- After implementing the above steps, the Institute will conduct technical registration tests for two separate seasons in the first growing season (https://spcri.ir/).

The plants new varieties registration and introduction process in Iran conduction based on UPOV guidelines for Distinctness, Uniformity, and Stability (DUS) trial and therefore involves demonstrating that the variety meets specific criteria, by conduction Distinctness, Uniformity, and Stability (DUS) trial for improved in Iran varieties or taking issued valid Distinctness, Uniformity, and Stability (DUS) trial results report by national focal point of new plants varieties registration in other countries for foreign varieties. Distinctness, Uniformity, and Stability (DUS) concept is the new plant variety must be distinguishable from existing varieties, exhibit uniformity in its characteristics, and maintain those characteristics across generations (Seed and Plant Certification and Registration Institute, 2019).

DUS testing is a way of determining whether a newly bred variety differs from existing varieties within the same species (the Distinctness part), whether the characteristics used to establish Distinctness are expressed uniformly (the Uniformity part) and that these characteristics do not change over subsequent generations (the Stability part). A DUS test is usually conducted in the field or glasshouse over two successive

growing seasons. During this period a number of mainly morphological characteristics are recorded both on the new (or candidate) variety and on similar varieties in what is known as "Common Knowledge". Differences, if they exist, are established by observation and measurement using internationally agreed protocols (Mozafari *et al*., 2010).

The drafting of the guidelines was carried out based on the guidelines of the International Union for the Protection of New Varieties of Plants (UPOV) and by considering important morphological, physiological and agronomic traits and resistance to biotic and abiotic stresses that play an effective role in differentiating plant varieties in the climatic conditions of Iran. The draft of each guideline was revised and approved after discussion and exchange of views in the Technical committee (Seed and Plant Certification and Registration Institute, 2008)

This act provides good quality seeds and planting stock to the farmers and encourage the farmers, breeders and private industries to develop new varieties. Distinctness, Uniformity and Stability (DUS) testing is obligatory for characterization and documentation of different traits of cotton varieties and parental lines. The variety to be protected must be unquestionably distinguishable by at least one essential character form other varieties. DUS characterization of cotton lines can be used for crop improvement by selection of better parents with specific trait which could be used in breeding program. There are total 34 DUS characters for tetraploid cotton including fiber characters. Out of these 34 characters the present was conducted for DUS testing of cotton lines for 20 different morphological traits or morphological markers using DUS testing manual of protection of plant variety & farmers rights authority (Mozafari *et al*., 2010).

Materials and Methods

For the purpose of the paper is a review on cotton new improved genotypes and cultivars Distinctness, Uniformity and Stability (DUS) trials conduction in order to registration, introduction and commercialization in Iran, reviewing on Uniformity and Stability (DUS) trials results conducted and published as research projects final reports and research papers by Hamidi *et al*. during 2010 to 2023 presented (Figure 1).



Figure 1. Cotton cultivars and new genotypes Distinctness, Uniformity and Stability (DUS) trial field in Kashmar cotton research station located at Khorasan Razavi province.

To observe, measure, and record quantitative and qualitative morphological characteristics, at least 20 plants from each plot are randomly selected, and all measurements and observations are made on these plants or parts of the plants. The 34 quantitative and qualitative morphological characteristics examined according to the International Guidelines for Distinction, Uniformity and Stability Tests in Tetraploid Cotton of the Union for the Protection of New Varieties of Plants (UPOV, 2018) are as follows: 1- Plant: type of flowering, 2-Flower: color of petal, 3- Flower: intensity of yellow color, 4-Petal: spot, 5- Flower: color of pollen, 6-Flower: position of stigma relative to anthers, 7- Plant: density of foliage, 8-Leaf: intensity of green color, 9- Leaf: shape, 10- Leaf: size, 11- Leaf: pubescence, 12- Leaf: presence of nectarines, 13-Stem: pubescence on upper part, 14-Stem: color, 15-Bract: dentation, 16-Bract: size, 17-Boll: size, 18-Boll: shape in longitudinal section, 19-Boll: pitting of surface, 20-Boll: length of peduncle, 21-Boll: prominence of tip, 22-Plant: shape, 23-Plant: height, 24-Boll: time of opening, 25-Boll: degree of opening, 26-Seed: density of fuzz, 27-Seed: color of fuzz, 28-Seed: 100 seed weight, 29-Boll: content of lint, 30-Fiber: length, 31-Fiber: strength, 32-Fiber: elongation, 33-Fiber: fineness and 34-Fiber: color(Table 1).

Table 1- Morphological characteristics examined according to the international guidelines for the Distinction, Uniformity and Stability (DUS) test for cotton (UPOV, 2018).

No.	Characteristics	Expression status	Signs	Notes
1	Plant: type of flowering	1-Clustered, 2-Semi-clustered, 3-non-clustered	(*) VG	1 2 3
2	Flower: color of petal	1-Whitish, 2-Yellow	VS	1 2
3	Flower: intensity of yellow color	1-Light, 2-Medium, 3-Dark	(*) VG	3 5 7
4	Petal: spot	1-Absent or very weak, 2-Weak, 3-Medium, 4-Strong, 5-very strong	VG	1 3 5 7 9
5	Flower: color of pollen	1-Whitish, 2-Medium yellow, 3-Dark yellow	MS	3 5 7
6	Flower: position of stigma relative to anthers	1-Clearly below, 2-Same level, 3-Clearly above	(*) (+)VG	1 2 3
7	Plant: density of foliage	1-Sparse, 2-Medium, 3-Dense	MS	3 5 7
8	Leaf: intensity of green color	1-Light, 2-Medium, 3-Dark	MS	3 5 7
9	Leaf: shape	1-Palmate, 2-Palmate to digitate, 3-Digitate, 4-Lanceolate	MS	1 2 3 4
10	Leaf: size	1-Small, 2-Medium, 3-Large	VG	3 ∘ 7
11	Leaf: pubescence	1-Absent or very weak, 2-Weak, 3-Medium, 4-Strong, 5-Very strong	(*) (+) VG	1 3 5 7 9
12	Leaf: presence of nectarines	1-Absent, 2-Present	MS	1 9
13	Stem: pubescence on upper part	1-Absent or very weak, 2-Weak, 3-Medium, 4-Strong, 5-Very strong	(*) VS	1 3 5 7 9

No.	Characteristics	Expression status	Signs	Notes
14	Stem: color	1-Green, 2-Reddish green	(*)	1 2 3 4
15	Bract: dentation	1-Fine, 2-Medium, 3-Coarse	VS	3 5 7
16	Bract: size	1-Very small, 2-Small, 3-Medium, 4-Large, 5-Very large	VG	1 3 5 7 9
17	Boll: size	1-Very small, 2-Small, 3-Medium, 4-Large, 5-Very large	VS	1 3 5 7 9
18	Boll: shape in longitudinal section	1-Circular, 2-Elliptical, 3-Ovate, 4-Conical	MS	1 2 3 4
19	Boll: pitting of surface	1-Fine, 2-Medium, 3-Coarse	MS	3 5 7
20	Boll: length of peduncle	1-Very short, 2-Short, 3-Medium, 4-Long, 5-Very long	(*) (+) MS/VG	1 3 5 7 9
21	Boll: prominence of tip	1-Weak, 2-Medium, 3-Strong	(+) VG	1 3 5
22	Plant: shape	1-Cylindrical, 2-Conical, 3-Globose	(*) (+) VG	1 2 3
23	Plant: height	1-Very short, 2-Short, 3-Medium, 4-Tall, 5-Very tall	(+) MG /MS	1 3 5 7 9
24	Boll: time of opening	1-Very early, 2-Early, 3-Medium, 4-Late, 5-Very late	(*) (+) MG	1 3 5 7 9
25	Boll: degree of opening	1-Weak, 2-Medium, 3-Strong	VG	3 5 7
26	Seed: density of fuzz	1-Absent or very sparse, 2-Sparse, 3-Medium, 4-Dense, 5-Very dense	VG	1 3 5 7 9

No.	Characteristics	Expression status	Signs	Notes
27	Seed: color of fuzz	1-White, 2-Grey, 3-Greenish, 4-Brownish	VG	1 2 3 4 5
28	Seed: 100 seed weight	1-Low, 2-Medium, 3-High	MG	3 5 7
29	Boll: content of lint	1-Very low, 2-Low, 3-Medium, 4-High, 5-Very high	MG	1 3 5 7 9
30	Fiber: length	1-Very low, 2-Low, 3-Medium, 4-High, 5-Very high	(*) VG	1 3 5 7 9
31	Fiber: strength	1-Very weak, 2-Weak, 3-Medium, 4-Strong, 5-Very strong	MG	1 3 5 7 9
32	Fiber: elongation	1-Very small, 2-Small, 3-Medium, 4-Large, 5-Very large	MG	1 3 5 7 9
33	Fiber: fineness	1-Fine, 2-Medium, 3-Coarse	MG	3 5 7
34	Fiber: color	1-White, 2-Colored	(*) VG	1 2

In the description table, asterisked characteristics (*) will be used for checking of all varieties and they are always exist in the description table except when the state of expression of a preceding characteristic or regional environmental conditions render this inappropriate. Expression status of the characteristic is given by notes.
Symbol (+) is given for the characteristic which is further explanation or illustrate at annex 1. Type for observation of characteristic as following:
- MG - Single measurement of a group of plants or parts of plants.
- MS - Measurement of a number of individual plants or parts of plants.
- VG - Visual assessment by a single observation of a group of plants or parts of plants.
- VS - Visual assessment by a single observation of a group of plans or parts of plants.

To measure the quantitative morphological characteristics of the fiber quality, which was carried out in the Cotton Fiber Technological Quality Laboratory of the Cotton and Fiber Plants Research Department of the Agricultural Research and Education Center of Tehran Province (Varamin), Golestan Province,

after harvesting each plot, standard fiber samples were prepared in an amount of at least 230 grams and placed at a temperature of 21.1 ± 0.6 C and a relative humidity of 65 ± 2% for 48 hours to standardize in terms of temperature and humidity. Then, the length, length uniformity, fineness, strength and degree of elasticity of the fibers were measured in the Cotton Fiber Technology Laboratory of the National Cotton Research Institute at the Agricultural Research and Education Center of Tehran Province (Varamin) using a measuring device for large volumes of cotton (HVI). For this purpose, 50 grains, a unit of weight equivalent to 24.3 grams of fiber, were placed in the chamber of the HVI device and constant air pressure was passed through the chamber. By bringing the volume of the chamber to a constant level and passing the air flow through it, the fineness of the fibers and the degree of fiber tension were determined in terms of percentage. Also, the degree of brightness (RD) and yellowness of the fibers (b+) were measured using the HVI device.

The analysis of variance of quantitative data in the Golestan province experiment was performed using MSTATC software and the comparison of means was performed using the least significant difference (LSD) test. The analysis of variance of qualitative data of Golestan province and Tehran province was performed using DUSTver. 6.0.1 and SAS (ver. 16) software. In general, the null hypothesis of the test for the differentiation of two cultivars based on quantitative traits is that the means of their corresponding traits are equal. If the difference between the means of two cultivars is greater than the minimum specified distance, they are considered as two distinct cultivars. For the differentiation test, qualitative morphological traits are used to assign cultivars to breeding groups. All genotypes are compared with each other in terms of all qualitative traits in pairs, and any two cultivars that differ in at least one trait are distinguished. The states of manifestation of qualitative and quasi-qualitative traits are converted to zero and one data. The calculation of coefficients between cultivars is done by the Dice method using morphological data and the relationship GSNL = [(N00 + N11) / (2N11 + N10 + N01)]. In this relationship, N11 and N00 are the number of states of manifestation of common and non-common traits between two cultivars, respectively, and N10 and N01 are the number of states of manifestation of the first and second cultivar, respectively. In order to analyze the data and group the genotypes based on the similarity coefficient matrix, UPGMA algorithm was used and NTSYS software was used.

Results and Discussions

Hamidi *et al*., 2016, for distinctness, uniformity and stability evaluation of cotton 13 cultivars morphological, conducted a research based on completely randomized blocks design conducted by four replications. Varamin, Sahel, Bakhtegan, Mehr, Oltan, Dr. Omoomi, Sepid, Pak, Khordad, Sealand, Armaghan, Golestan cultivars and No.200 thirty nine morphological characteristics of their measured. Petal color and base color spot intensity qualitative morphological characteristics divided cultivars into two groups, Dr. Omoomi grouped in one group and others grouped in other group. Based

on pollen color Bakhtegan and Sahel cultivars in one group and others in other group settled. Pubescence of stem and plant form separate those cultivars into distinct groups. Oltan, Varamin, Mehr, Pak, Sealand, Khordad, Sepid, Armaghan and Golestan cultivars based on flowering type divided into three distinct. Boll longitude cut form distinct Mehr, Pak, Sealand, Armaghan and Golestan cultivars into three groups and Pak, Sealand and Golestan cultivars in one group and Mehr and Armaghan each in one group. Based on stigma position to anthers Pak and Sealand cultivars in one group and Golestan in other group settled Also on the basis of toothed bracts and boll shallow holes Pak and Sealand distinct each another. Leaf shape separated Varamin, Khordad and Sepid cultivars into two groups and Varamin and Khordad cultivars in one group and Sepid cultivar settled in other group. Finally by stigma position to anthers characteristic separated Varamin and Khordad cultivars and all cultivars separate from each other's (Figures 2 to 9).



Figure 2. Petal color and petal spot are distinct from two cultivars, Sea Island variety Doctor Omumi with medium yellow petals and a very strong petal spot (right) and Varamin Upland cultivar with whitish petals and without petal spot (left) (Hamidi *et al*., 2016).

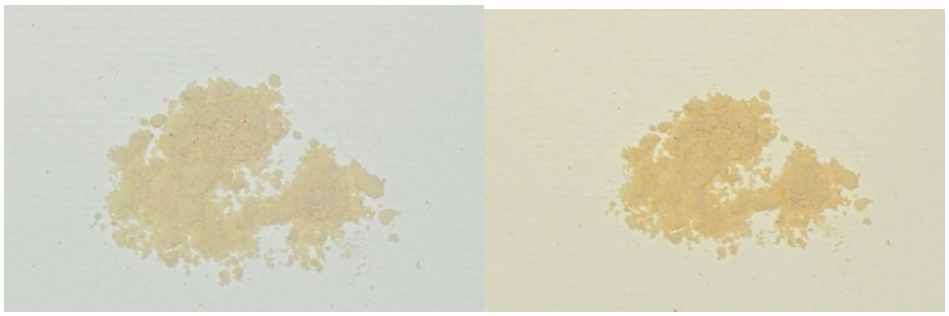


Figure 3. Differentiation of pollen color between the Upland Varamin cultivar with whitish colored pollen (right) and the Sahel Upland cultivar with medium yellow colored pollen (left) (Hamidi *et al*., 2016).



Figure 4. Differentiation of the ovate boll of the Sealand variety (right) and the circular boll of the Mehr variety (left) (Hamidi *et al*., 2016).



Figure 5. Boll fin pitting on surface the Pak variety (right) and medium pitting on surface of the Sealand variety boll (left) (Hamidi *et al*., 2016) .



Figure 6. The higher position of the stigma and stamens of the cultivar Sealand (right) and the parallel position of the stigma and stamens in the cultivar Golestan (left) (Hamidi *et al*., 2016).



Figure 7. The clearly above position of the stigma relative to the anthers in the Khordad cultivar (right) and the same level position of the stigma relative to the anthers in the Varamin cultivar (left) (Hamidi *et al*., 2016).



Figure 8. Medium dentation bracts at green maturity of the cultivar 'Sealand' (right) and 'Pak' long- dentation bracts at green maturity (left) (Hamidi *et al*., 2016).



Figure 9. Differentiation between the pPalmate leaves of the Varamin cultivar (right) and the digitate like leaves of the Sepid cultivar (left) (Hamidi *et al*., 2016).

Hamidi, 2018, in order to evaluation of distinctness, uniformity and stability(DUS) of quantitative and qualitative morphological characteristics of 23 Upland (*Gossypium hirsutum* L.) and Seailand (*G.barbadense*) cotton cultivars and new genotypes: 1- NSK- B23, 2- NN2A19, 3- NNC(Latif), 4- K8801 (Kashmar), 5- K8802(Khorshid**)**, 6- Eram-3, 7- SKT-133, 8- N2G-80, 9- M-16, 10- M-14,11- M-13,12- CRI-871, 13- TBL-60, 14- CRI-114, 15- CRI-114 ,15-CRI-108, 16- NSK-847, 17- SKN2773, 18- Lambright, 19- Leaf-red, 20- Mehr, 21- No. 200, 22- No. 210, 23- No. 221, 24- Okra Leaf-Red, 25- Opal, 26- Oultan, 27- Pak, 28- Q-30, 29- Red Leaf, 30- Sahel, 31- Sealand, 32- Sepid, 33- Sicala 33, 34- Sp-731, 35- S-R-1, 36- Super okra, 37- Tabladila, 38- Termez 14, 39- Varamin, 40- Zeta- 2, 41-73-S-485, 42-73-S-484, this research was conducted in 2016-2017 at Hashem Abad cotton research station of Cotton Research Institute(CRI) in Golestan province, Tehran provinces Agriculture and Natural Resources Research Center in Varamin and Seed and Plant Certification and Registration Institute(SPCRI) at Karaj. Evaluated cultivars and genotypes pure lines seeds planted as recommended planting date and plant density based on complete randomized blocks design by 4 replications and all ordinary cultivation operations conducted. During experiment, 39 quantitative and qualitative morphological characteristics recorded and measured according to the national Cotton Distinctness, Uniformity and Stability (DUS) testing guideline. Results only completed for Golestan province and showed studied genotypes have not any difference for qualitative morphological characteristics. Results also showed studied genotypes quantitative characteristics including: fiber strength, number of nodes to the lowest fruiting branch, fiber fineness, boll length of peduncle, fiber length uniformity, plant height and fruiting branch average internode length had significant difference among them and distinct with each other's.

In order to evaluate of distinctness, uniformity and stability (DUS) of morphological traits, three new genotype s of cotton: GT, TBL and SKT, Hamidi *et al*., 2018 were tested using a complete randomized blocks design with replications. In general, quantitative and qualitative morphological characteristics were measured. Results showed quantitative morphological characteristics including number of stem nodes to the lowest fruiting branch (at flowering stage),

fruiting branch length, fruiting branch nodes number, ginning outturn, fiber length, elongation and fineness, plant height and boll petiole length of genotypes significantly were distinct. Also genotype s qualitative morphological characteristics: pollen color, position of stigma relative to anthers, bract size (at green maturity), type of flowering, intensity of leaf green color (at flowering stage), Leaf size and pubescence of lower side, stem pubescence in upper part, boll opening time (when of the plants have at least one boll opened) and degree of opening (at full maturity) significantly were distinct. Generally, achieved results showed, GT genotype based on yellow pollen color, upper position of stigma relative to anthers, small leaf size, medium stem pubescence in upper part, short plant height (at green maturity) and early boll time of opening (when of the plants have at least one boll opened) was distinct from TBL and SKT genotypes. Also TBL genotype due to non -clustered type of flowering, medium leaf intensity of green color (at flowering stage), medium bract size (at green maturity) and medium boll petiole length were distinct from SKT genotype. Therefore, this research results characterized distinct morphological characters having uniformity and stability of three cotton new genotypes in the course of introduction as cultivars which could be used for mentioned cultivars registration for having plants breeders' right. Also, with due attention to uniformity and stability of distinctness of eight qualitative morphological characteristics, can used these characteristics as descriptors of cultivars which would introduced for those genotypes seed production fields control and certification of genetically purity and genuineness.

Hamidi, 2019**,** In order to evaluation of distinctness, uniformity and stability(DUS) of quantitative and qualitative morphological characteristics of 6 Upland (*Gossypium hirsutum* L.) cotton new genotypes: 1- SK6, 2- GKSK4, 3-96A, 4- GKTB113, 5- ANBK and 6- ANBK414 and control cultivars: 1- Varamin and 2- Golestan the research was conducted with collaboration of Cotton Research Institute(CRI) during 2019-2021 at Hashem Abad cotton research station of Cotton Research Institute(CRI) in Golestan province and Seed and Plant Certification and Registration Institute(SPCRI) at Karaj. Evaluated genotypes pure lines seeds planted as recommended planting date and plant density based on complete randomized blocks design by 4 replications and all ordinary cultivation operations conducted. During experiment, 39 quantitative and qualitative morphological characteristics recorded and measured according to the national Cotton Distinctness, Uniformity and Stability(DUS) testing guideline. Results showed studied genotypes with each other's and control cultivars had uniform and stable distinctness.

Hamidi *et al*., 2020, in order to 36 cotton cultivars and genotypes qualitative morphological characteristics evaluation, in this research, during 2012 to 2013 years in Tehran provinces Agriculture and Natural Resources Research Center at Varamin and Seed and Plant Certification and Registration Institute(SPCRI) at Karaj 22 qualitative morphological characteristics studied. Results indicated that, cultivars and genotypes distinct for 11

qualitative morphological characteristics. Based on color of petal cultivars and genotypes divided into 2 distinct yellow and cream petal color groups. All yellow petal color group cultivars, were Sea Island cottons and all cream petal color group cultivars and genotypes were Upland cottons. Among yellow petal color cultivars, for the reason of same level of position of stigma relative to anthers, medium bract dentations at green maturity and strong leaf lower side density of pubescence, Termez 14 cultivar distinct from 2 other cultivars. Cream petal color cultivars and genotypes also based on leaf shape distinct into 2 palmate and lanceolate groups. Lanceolate group cultivars and genotypes were 3 cultivars, Sepid, Okra Leaf-Red and Super okra which among their boll shape in longitudinal section and seed color of fuzz distinct 3 cultivars from each other. Palmate leaf shape cultivars and genotypes group which amounted to 31 of evaluated cultivars and genotypes, based on boll shape in longitudinal section divided to 3 main groups. 20 cultivars and genotypes of this group which were cultivars and genotypes with ovate boll shape in longitudinal section also based on 7 characteristics, boll pitting of surface, bract dentations at green maturity (Figure 10 to 18).



'igure 10. Petal color differences in Sea Island cotton varieties with yellow color Giza, Termez14, and Doctor Omumi (from right to left, respectively) and Upland Avangard with cream color petals (Hamidi *et al*., 2020).



Figure 11. Differentiation the clearly above (right and middle) and same level (left) positions of the stigma relative to the anthers in the Sea Island cultivars, Doctor Oummi, Giza and Termez 14, respectively(Hamidi *et al*., 2020).



Figure 12. The distinction between fine, medium and coarse dentation of the bracts at green maturity of the evaluated Sea Island varieties, from right to left, in the Sea Island varieties Termez14, Dr. Oummi, and Giza and frego bracts in Upland cotton Frego bract variety (Hamidi *et al*., 2020).



Figure 13. Differentiation of leaf shape in Upland cotton cultivars, palmate leaves of the cultivar Belly Izovar (right) and lanceolate leaves of the cultivar Super Okra (Hamidi *et al*., 2020).

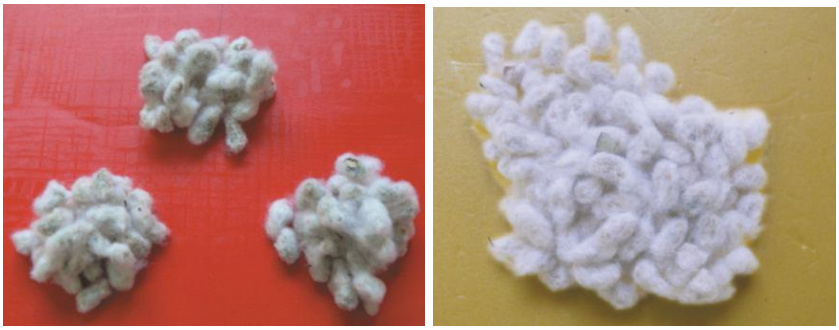


Figure 14. Differentiation of the gray and white color of the seed coat fuzz in the Sepid and Super Okra Upland cotton varieties, from right to left, respectively (Hamidi *et al*., 2020).



Figure 15. Medium and high dense fuzz on the seed, from right to left, in the Upland cotton varieties Khordad and Avangard, respectively(Hamidi *et al*., 2020).



Figure 16. Anthocyanin content of flower petals and leaves of Upland cotton cultivars Okra Red Leaf (right and middle, respectively) and leaves of the Red Leaf cultivar (Hamidi *et al*., 2020).

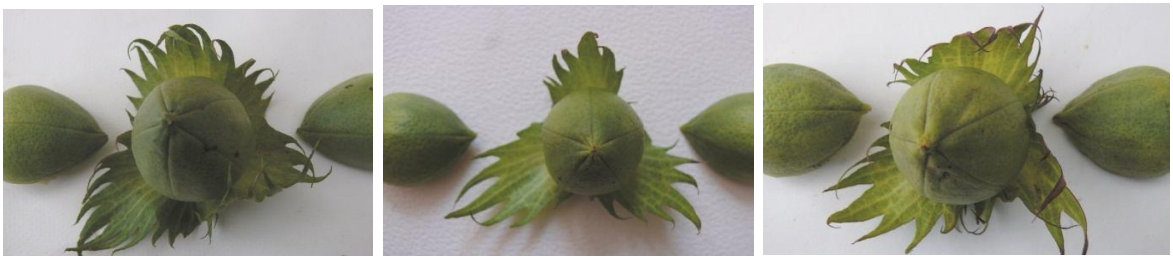


Figure 17. Differentiation of round, ovoid and conical shape of the boll in longitudinal section of Upland cotton varieties Lambreit, Sealand and Ultan, respectively, from right to left (Hamidi *et al*., 2020).



Figure 18. Globose and conical plant shape at green maturity in the medium-sized Hopicala and Tabladilla cultivars, from right to left, respectively (Hamidi *et al*., 2020).

The objective of Hamidi *et al*., 2022 research was to evaluate six newly introduced cotton genotypes for some quantitative and qualitative traits, distinctness, uniformity and stability (DUS) to assess potential crop production and agronomic ability as new varieties, and to establish a reference collection of morphological traits for the purpose of identifying the necessary morphological descriptors for genetic purity and determining the authenticity of the varieties in the subsequent control of commercial seed production. **Therefore,** seed cotton yield, number of bolls per plant, boll weight, and earliness of 34 quantitative and qualitative morphological traits of six new promising genotypes of Uplandcotton (*Gossypium hirsutum* L.): 1- SK6, 2- GKSK4, 3-96_A3, 4- GKTB113, 5- ANBK and 6- ANBK414 compared with control cultivars: 1- Varamin and 2- Golestan in 2019 and 2020 according to the International Guidelines for the

Conduct of Distinctness, Uniformity and Stability (DUS) Tests evaluated as a complete block trial with four replicates. **Results indicated.** The new genotypes ANB414 and ANBK had the highest cotton seed yield and the highest number of bolls per plant, and the new genotype 96_A3 was the earliest genotype. In addition, the new genotypes ANB414 and GKTB113 had the highest fiber length and extension and were superior to the control cultivars and other genotypes studied. The new cotton genotypes resembled the control cultivars in 12 qualitative morphological traits and differed from other new genotypes in 22 qualitative morphological traits. The results of the quantitative traits studied showed that the new genotypes ANB414 and ANBK had the highest cotton seed yield and the highest number of bolls per plant, while the new genotype 96_A3 had higher earliness, while the new genotypes ANB414 and GKTB113 had the highest fiber length and extension compared to the control varieties. In addition, the studied new cotton genotypes were distinguishable based on various studied morphological characteristics compared to each other and to the control cultivars and had uniform and stable distinctness. Therefore, the studied new cotton genotypes are potentially suitable for introduction as new varieties.

Hamidi, 2023, in order to evaluate the distinctness, uniformity and stability(DUS) of quantitative and qualitative morphological characteristics of 3 new improved promising lines of cotton resulting from the crossing of two diploid *Gossypium arboreum* and *Gossypium herbaceum* species including: 1- DK-92-11 -, 2-DK-92-17 and DK-92-19 and the native cotton population Male, a joint research in cooperation of Seed and Plant Certification and Registration Institute (Karaj), Agriculture and Natural Resources Research and Education Center of Razavi Khorasan Province (Kashmar, Faizabad, Sabzevar and Neishabur Agricultural and Natural Resources Research Stations), South Khorasan Province Agriculture and Natural Resources Research and Education Center (Mohammadiyeh - Birjand Agricultural and Natural Resources Research Station) during 2020-2021. Seeds of pure lines, improved promising lines and Maleh native cotton population accessions registered in the National Gene Bank of Seed and Plant Improvement Institute (SPII) seeds with the recommended plant density and planting date were sown and all cultivation operations were carried out as ordinary. The measurement and recording of 34 quantitative and qualitative morphological characteristics of them were carried out according to the International Union for the Protection of New Varieties of Plants (UPOV) international guideline for cotton distinctness, uniformity and stability (DUS) trials. Qualitative characteristics of cotton fibers were determined in the Cotton Fibers Technological Quality National Reference Laboratory in the Agriculture and Natural Resources Research and Education Center of Tehran province (Varamin). Based on the results of this research, DK-11-92 promised line was superior to the control cultivars and 2 other lines in terms of 9 quantitative characteristics: 1216.50 kg/ha seed cotton yield, vegetative branches number, the mist open bolls number, the lowest boll number, gin turn out, 100 seeds weight, fibers length, uniformity, and strength.

Whereas DK-17-92 and DK-3-19-92 promising lines were superior in terms of 6 and 5 quantitative studied characteristics, respectively. In addition, the improved promising diploid lines and the Maleh native cotton population compared to each other and the control cultivars were similar in terms of 23 morphological studied traits and were different in terms of 11 morphological studied traits and their distinctness was uniform and stable. Therefore, the investigated promising improved diploid lines were new and had uniform and stable distinctness to be registered as cultivars. Also, the Maleh cotton native population can be registered as a national native plant germ plasm.

Hamidi *et al*., 2024, evaluated the seed cotton yield, its components, earliness, fiber quality and morphological characteristics distinctness, uniformity and stability of three tolerant to the salinity stress cotton new hybrid genotypes: TB52, SB26 and TJ82 were evaluated in comparison to two commercial common cultivated cultivars Hekmat and Golestan as control. Materials and methods: This research was carried out at the Cotton Research Institute (Gorgan-Hashem Abad and Kordkuy Karkandeh Cotton Research Stations and Darab Agricultural Research Station) and the Seed and Plant Certification and Registration Institute (Karaj) during 2020-2021 years. The evaluated traits are plant height, length and number of vegetative and reproductive branches, number and weight of bolls, seed cotton yield, earliness index, length, strength, elasticity, fineness index, uniformity, reflectance degree and yellowness of fibers, height of the first reproductive branch from the ground, leaf size , boll peduncle length and 100 seeds weight and 34 quantitative and qualitative morphological characteristics were according to the international guidelines for distinctness, uniformity and stability test (DUS) of cotton. The results showed that the tolerant to the salinity new hybrid cotton genotype TJ82 was superior to the other studied tolerant to the salinity new hybrid cotton genotypes. Also, the results of the evaluation of quantitative trait distinctness of tolerant to salinity new hybrid cotton genotypes in Alborz province (Karaj) showed that the tolerant to salinity new hybrid cotton genotype TJ82 in terms of 5 quantitative traits, 100 seeds weight, plant height, strength, uniformity and reflectance degree of fibers and the tolerant to salinity new hybrid cotton genotype TB52 was superior in terms of 4 quantitative traits: boll peduncle length and fiber length, strength and fitness. Based on the results of this research, the new tolerant to salinity cotton hybrid genotype TJ82 can be selected as a new cultivar for introduction. Also, in general, the evaluation of distinctness, uniformity and stability of introducible new tolerant to salinity hybrid cotton genotypes showed that these genotypes had stable distinctness and uniformity in terms of 22 morphological traits. Therefore, referring to the provisions of considering the newness of the investigated new tolerant to salinity hybrid cotton genotypes and their distinction from previously registered or known cultivars in terms of morphological characteristics and appearance uniformity, these genotypes can be registered.

Conclusion

Based on International Union for Protection of New Varieties of Plant

(UPOV) guidelines for the conduct of test for distinctness, uniformity and stability(DUS) trials during 2010 to 2023 by conducting Distinctness, Uniformity, and Stability (DUS) trials 96 common and new cotton cultivars and genotypes Distinctness, Uniformity, and Stability evaluated and many commercial cultivars registered Iran. Varieties and genotypes including upland and sea Island and Desi cotton Iranian and foreign cultivars and genotypes.

References:

Acquaah, G. 2012. Principles of Plant Genetics and Breeding (Second Edition). John Wiley & Sons, Ltd

Ahmad, S. and Hasanuzzaman, M. 2020. Cotton Production and Uses Agronomy, Crop Protection, and Postharvest Technologies. Springer Nature Singapore Pte Ltd.

Agricultural Insurance Fund, 2013. Developing standards for determining potential and assessing damage by separating management and force factors at different growth stages in cotton fields. Agricultural Bank.

Alishah, O. 2013. Cotton genetics and breeding. Iran University Press.

Barzali, P. 2020. Introduction to the cotton plant and its genetic modification methods. Eshkaf Publishing.

Evenson, R.E. and Gollin, D. 2003. Crop Variety Improvement and its Effect on Productivity the Impact of International Agricultural Research. CABI Publishing.

Farsi, M. and Bagheri, A.R. 2023. Plants breeding principles. Mashhad Jihad-e-Daneshgahi Publication.

Habiba, S. and Heidari, R. 2014. Scope of intellectual property rights in new plant varieties. Private Law Studies Quarterly, 44(2-2): 155-174.

Hamidi, A., 2018. Evaluation of distinctness, uniformity and stability of Cotton (*Gossypium hirsutum* L.) new cultivars and genotypes by using morphological characteristics. Seed and Plant Certification and Registration Institute (SPCRI) and Cotton Research Institute (CRI), Agriculture Research, Education and Extension Organization, Ministry of Jahad-e-Agriculture.

Hamidi, A. 2019. Evaluation of distinctness, uniformity and stability of 6 Cotton (*Gossypium hirsutum* L.) new genotypes by using morphological characteristics. Seed and Plant Certification and Registration Institute (SPCRI) and Cotton Research Institute (CRI), Agriculture Research, Education and Extension Organization, Ministry of Jahad-e-Agriculture.

Hamidi, A. 2023. Evaluation of distinctness, uniformity and stability (DUS) of Diploid (*Gossypium* arboreum L. and *G. herbaceum* L.) promising lines and Malle Cotton Population by using morphological characteristics. Seed and Plant Certification and Registration Institute (SPCRI) and Cotton Research Institute (CRI), Agriculture Research, Education and Extension

Organization, Ministry of Jahad-e-Agriculture.

Hamidi, A., Naderi Arefi, A., Forghani, S. R., Vafayi Tabar, M., Arab Salmani, M., and Hakimi, M. 2012. Cotton Seed Production and Technology. Seed and Plant Certification and Registration Institute, Karaj, Iran.

Hamidi, A., Ghasemi Bezdi, K., Baniani, E., Hekmat, M.H., Alishah, O., Arabsalmani, M., Vafaeetabar, M., Miri, A.A. and Khazaei, F. 2016. Evaluation of distinctness, uniformity and stability of Cotton (*Gossypium hirsutum* L. and *G. barbadense*) common and new cultivars by using morphological characteristics. Iranian Cotton Research Journal, 3(2): 1-25.

Hamidi, A. Ghasemi Bazdi, K. and Jafari, Y. 2018. Evaluation of Morphological Characteristics of Cotton (*Gossypium hirsutum* L.) New Genotypes in Golestan Province. Journal of Crop Breeding, 10(27): 66-74.

Hamidi, A., Vafaeetabar, M., Baniani, E., Khazaei, F. 2020. Evaluation of distinctness, uniformity and stability of some Upland (*Gossypium hirsutum* L.) and Sea Island (*G. barbadense*) Cotton cultivars and genotypes morphological characteristics. 7(2-14): 93-114.

Hamidi, A., Alishah, O., Rahemi, M.R., Mohajer Abbasi, A., Jafari, Y., Hoseinpoor, J., Ghasemi Bezdi, K., Jazaeri Noosh Abadi, M.R. and Najafian, M. 2022. Evaluation of some quantitative and qualitative characteristics of six newly introduced genotypes of cotton (*Gossypium hirsutum* L.). 9(2-16): 179-201, 10.22092/IJCR.2022.359154.1184

Hamidi, A., Fathi Sadabadi, M., Zangi, M.R., Jazaieri Noosh Abadi, M.R., Sharafizad, M., Najafian Fakhrai, M., Alishah, O., Nattaj Aghamahali, M.R., Vanda, M., Hamid, R. 2024. Evaluation of seed cotton yield, its components, earliness, fiber quality and morphological characteristics distinctness, uniformity and stability of three Cotton (*Gossypium hirsutum* L.) new introducing tolerant to salinity hybrid genotypes. Iranian Journal Cotton Researches, 12 (1), 41-60, 10.22092/ijcr. 2024.366840. 1224.

International Cotton Advisory Committee, 2003. Current research projects in cotton. International Cotton Advisory Committee. Technical Information Section. International Cotton Advisory Committee.

International Union for Protection of New Varieties of Plant, 2018. Guidelines for the conduct of test for distinctness, uniformity and stability UPOV Code(s): GOSSY *Gossypium* L. International Union for Protection of New Varieties of Plant (UPOV), Paris.

Maiti, R., Kumari, Ch. A., Samsul Huda, A.K., Mandal, D. and Begum, S. 2020. ADVANCES IN COTTON SCIENCE Botany, Production, and Crop Improvement. Apple Academic Press Inc.

Monostoei, T. 2014. Crop Production. University of Szegd Faculty of Agriculture.

Mozafari, J., Sadeghian, S.Y., Mobasser, S., Hkademi, H. and Mohammadi, S.A. 2010. Principles of plant variety protection. Ministry of Jihad-e-Agriculture Agricultural Research Education and Extensions Organization (AREEO), Seed and Plant Certification and Registration Institute (SPCRI).

Sadeghian Motahar, S.Y. 2008. Principals of plant breeding: field and horticultural crops. Agriculture Education Publication, Extension and Education Deputy of Agriculture, Research, Education and Extension Organization (AREEO) of Jahad Agriculture Ministry. Karaj.

Seed and Plant Certification and Registration Institute, 2008. National Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability in Tetraploid Cotton. Seed and Plant Certification and Registration Institute (SPCRI).

Seed and Plant Certification and Registration Institute (SPCRI). 2019. Act of plant varieties registration, control and certification of seed and plant material, Islamic Republic of Iran. Seed and Plant Certification and Registration Institute (SPCRI).

Yazdi Samadi, B. and Abd Mishani, S. 1997. Breeding field crops. Iran University Press.