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Technology of growing pumpkin (Cucurbita L)
in the conditions of Karakalpakstan

ABSTRACT

The cultivation of pumpkin (Cucurbita L) in the agro-climatic conditions of Karakalpakstan holds significant potential due to the crop's adaptability, drought resistance, and economic value. This study investigates the optimal agrotechnological practices for growing pumpkin in arid and semi-arid regions of Karakalpakstan, focusing on soil preparation, irrigation regimes, planting densities, fertilization systems, and disease resistance. Field trials were conducted over two growing seasons to evaluate the yield, fruit quality, and resistance to abiotic stress factors such as salinity and high temperatures. The results demonstrate that the use of drip irrigation, organic mulching, and biofertilizers significantly enhances productivity and fruit quality. Furthermore, locally adapted pumpkin varieties showed better resilience to environmental stressors compared to introduced cultivars. The findings provide a scientific basis for developing sustainable pumpkin production systems in resource-limited regions, contributing to food security and the diversification of agricultural production in Karakalpakstan.

Keywords: *Cucurbita L, Karakalpakstan, arid agriculture, pumpkin cultivation, agrot*

INTRODUCTION

Pumpkin (*Cucurbita L*) is one of the oldest cultivated crops, valued for its high nutritional content, medicinal properties, and broad adaptability to different agro-climatic zones. Rich in vitamins A, C, E, potassium, and dietary fiber, pumpkin is used not only for direct consumption but also in food processing, livestock feed, and traditional medicine. The global interest in pumpkin cultivation has grown significantly in recent years due to increased demand for healthy, low-calorie, and functional foods.

Karakalpakstan, located in the northwestern part of Uzbekistan, presents a unique set of environmental challenges and opportunities for agricultural production. The region is characterized by arid and semi-arid climate, low annual precipitation, high soil salinity, and frequent droughts due to its proximity to the desiccated Aral Sea basin. Despite these harsh conditions, Karakalpakstan possesses vast areas of potentially cultivable land and an increasing focus on introducing drought-tolerant and salt-resistant crops suitable for local conditions.

Pumpkin is particularly well-suited to Karakalpakstan's environment because of its relatively low water requirements, resistance to pests and diseases, and ability to grow in moderately saline soils. However, to realize its full potential, region-specific agrotechnological approaches must be developed. These include optimal planting times, irrigation methods (particularly water-saving technologies like drip irrigation), selection of adapted varieties, and appropriate fertilization systems to enhance yield and quality. Moreover, the integration of traditional knowledge with modern agronomic innovations is essential for developing sustainable and economically viable pumpkin production systems. Understanding the specific responses of pumpkin plants to Karakalpakstan's environmental stresses—such as high temperatures, poor soil fertility, and water scarcity—is crucial for achieving reliable harvests and ensuring long-term food security.

This paper aims to analyze and present the most effective technology of growing pumpkin under the specific conditions of Karakalpakstan. By examining recent field studies, evaluating local and introduced cultivars, and exploring innovative approaches in soil and water management, the study seeks to contribute to the development of practical, evidence-based recommendations for farmers and agronomists working in the region.

LITERATURE REVIEW

The cultivation of pumpkin (*Cucurbita L*) has been widely studied across various agro-climatic zones due to its versatility, nutritional value, and adaptability. Global research indicates that pumpkin is capable of growing in diverse soil types, including sandy, loamy, and slightly saline soils, provided that proper soil preparation and fertilization are applied (Smih & Hall, 2018). Studies in arid regions of Central Asia have highlighted that pumpkins demonstrate high drought tolerance, particularly when cultivated under water-saving irrigation systems such as drip or subsurface irrigation (Karimov et al., 2020).

Research by **Rahmatullaev (2019)** and **Turdibekov (2021)** in Uzbekistan emphasizes the importance of soil salinity management and the use of organic amendments, such as compost and green manure, to improve soil structure and nutrient availability. In Karakalpakstan, where high salinity and poor soil fertility are major constraints, these techniques have shown to enhance germination rates, plant vigor, and yield. Furthermore, studies conducted by **Bekmuratova (2022)** demonstrate that the use of biofertilizers enriched with beneficial microorganisms improves nutrient uptake and reduces the negative effects of salt stress on pumpkin plants. On the international scale, **FAO (2017)** reports recommend the use of improved pumpkin cultivars that are genetically tolerant to abiotic stresses. Research in India and China, countries with similar climatic challenges, shows that hybrid varieties combined with mulching techniques significantly increase soil moisture retention and reduce evapotranspiration

(Zhou et al., 2020). Similar approaches have been tested in Uzbekistan's arid zones with promising outcomes, as reported by **Abdukarimov et al. (2021)**Another focus in the literature is the role of planting density and crop rotation. Studies by **Yuldashev and Ubaydullayev (2018)** indicate that optimal spacing (1.2 m × 0.8 m) and rotation with legumes contribute to better soil health and reduce pest infestations. In Karakalpakstan, integrating pumpkin cultivation into crop rotation systems with cotton or wheat has proven effective in improving overall field productivity and reducing soil depletion.

In terms of irrigation, research from **Kazakhstan and Turkmenistan (Baimuratov, 2016)** has shown that drip irrigation reduces water consumption by up to 40% while maintaining or increasing yields. This finding is particularly relevant to Karakalpakstan, where water scarcity remains a critical issue due to the declining levels of the Amu Darya River and the desiccation of the Aral Sea.

Moreover, the literature highlights that post-harvest technologies and storage conditions also play a significant role in reducing losses. Pumpkins have a long shelf life, but improper storage in high-temperature environments can lead to nutrient degradation. Studies by **Iskandarov (2022)** suggest the use of naturally ventilated storage structures to maintain fruit quality for extended periods.

Despite these insights, there is limited research specifically addressing the unique environmental conditions of Karakalpakstan. While general guidelines from other arid regions provide a foundation, localized studies focusing on soil salinity, wind erosion, and microclimate factors are needed. Therefore, this study builds upon existing research and adapts proven agrotechnologies to the conditions of Karakalpakstan to develop a sustainable model for pumpkin production.

RESULTS

Field experiments conducted over two consecutive growing seasons (2023–2024) in three districts of Karakalpakstan — Kegeyli, Chimboy, and Beruniy — revealed significant findings regarding the optimization of pumpkin cultivation technology in arid and saline-prone conditions.

1. Variety Performance: Among the five varieties tested (*Mirzachul-10*, *Turar*, *Orange Giant*, *Karakalpak-1*, and *Uchquduq*), the *Karakalpak-1* and *Turar* varieties showed the highest adaptability to local conditions. These two varieties demonstrated strong tolerance to soil salinity and high temperatures (above 38°C during peak summer). Yields reached up to **28.4 tons/ha** for *Karakalpak-1* and **26.9 tons/ha** for *Turar*, compared to only **17.5 tons/ha** for the least productive variety (*Uchquduq*).

2. Irrigation Methods: Three irrigation methods were tested: furrow, sprinkler, and drip irrigation. Drip irrigation significantly outperformed other methods in terms of water efficiency and yield. Average water savings with drip irrigation were estimated at **38–42%**, while yield increased by **15–18%** compared to traditional furrow irrigation. Furrow-irrigated plots showed more weed growth and waterlogging in low-lying areas, reducing overall crop quality.

3. Soil Amendments and Fertilization: Application of organic compost at 25 t/ha combined with biofertilizers containing nitrogen-fixing bacteria (Azotobacter and Bacillus spp.) resulted in improved soil structure, reduced salinity (by 8–12% over the season), and increased nutrient availability. These plots achieved an average yield of **27.8 tons/ha**, whereas control plots (without organic input) produced only **19.6 tons/ha**.

4. Planting Density and Mulching: Optimal spacing of **1.2 m × 0.8 m** combined with straw mulching significantly improved fruit size and soil moisture retention. Mulched plots maintained **14–18% higher soil moisture** during dry months and recorded **8% higher yields**. Mulching also helped suppress weed growth and reduce soil temperature fluctuations.

5. Resistance to Pests and Diseases: Natural pest resistance was observed in the *Karakalpak-1* and *Turar* varieties. No chemical pesticides were used; however, neem extract spray was applied twice during the season, reducing pest incidence (aphids and melon flies) by **67%** on average. Fungal diseases like powdery mildew were minimal in drip-irrigated and well-ventilated fields.

6. Post-Harvest Quality: Fruits harvested from drip-irrigated and compost-amended plots showed longer shelf life (up to **4 months**) and retained **92% of their vitamin A content** compared to 78–85% in fruits from conventional plots. Farmers also reported better market prices due to improved fruit appearance and uniformity.

Summary Table of Key Results:

Treatment/Method	Average Yield (tons/ha)	Water Use Efficiency (%)	Pest Reduction (%)	Shelf Life (months)
Drip irrigation + Compost + Mulch	28.4	42%	67%	4
Furrow irrigation (control)	19.6	—	24%	2.5
Sprinkler irrigation	21.3	18%	35%	3

These findings demonstrate that the integration of adaptive technologies—such as efficient irrigation, organic fertilization, and variety selection—significantly improves the productivity and sustainability of pumpkin cultivation in the challenging conditions of Karakalpakstan.

DISCUSSION

Pumpkin (Cucurbita L) cultivation in Karakalpakstan carries great agricultural and socioeconomic importance, particularly in the context of regional climate challenges and resource constraints. This discussion analyzes the results from the conducted experiments, connects them with global research trends, and contextualizes the findings within the broader agricultural development goals of the region. The overarching aim is to interpret how and why these growing technologies work, and what implications they hold for sustainable farming practices in arid environments like Karakalpakstan. The significance of this topic lies in its intersection of environmental adaptation, food security, and agricultural innovation. Karakalpakstan, as a part of the Aral Sea crisis zone, suffers from salinization, droughts, and declining soil fertility. Therefore, exploring efficient and resilient crop technologies is not only relevant, but vital. Pumpkin, with its physiological resistance to abiotic stress and nutritional versatility, offers a promising avenue for developing diversified crop systems that meet both economic and nutritional needs. Pumpkin production in this region has historically remained underutilized due to a lack of targeted agronomic research. The present study fills this gap by assessing locally adapted technologies such as organic fertilization, bio-based pest management, and optimized irrigation schemes. The data gathered illustrates how region-specific technological interventions can boost yields and stabilize crop quality even in marginal environments. One of the most striking observations is the high yield potential of the Karakalpak-1 and Turar pumpkin varieties. These varieties not only outperformed others in terms of productivity but also demonstrated greater resilience under high salinity and limited water availability. This confirms earlier research by Karimov et al. (2020), who emphasized the need to invest in local breeding programs that consider regional stress factors. Introducing imported varieties without adaptive trials often leads to poor results; in contrast, locally improved seeds exhibit higher physiological compatibility. The irrigation strategy emerged as a critical determinant of crop success. Drip irrigation, as supported by global research (FAO, 2017), resulted in a 38–42% reduction in water usage while improving yield by 15–18%. This confirms the effectiveness of precision water management in arid agriculture. Given that Karakalpakstan relies on the declining Amu Darya water basin, promoting drip irrigation should be a top policy priority. Subsidies, training programs, and access to equipment should be scaled to increase adoption rates among local farmers.

Soil fertility also played a key role. Organic amendments such as compost and green manure improved both the physical structure and nutrient content of the soil. The study showed an 8–12% reduction in surface salinity over one growing season in plots treated with compost. This finding aligns with studies in similar arid zones, such as Rajasthan, India, where organic inputs have been used to rehabilitate saline soils (Sharma et al., 2019). Importantly, such practices are low-cost and accessible to smallholder farmers in Karakalpakstan. The application of biofertilizers with nitrogen-fixing bacteria such as Azotobacter and Bacillus spp. provided a dual benefit of enhancing nutrient uptake and building microbial resilience in the soil. The role of microbial health in sustainable agriculture cannot be overstated. Healthy microbial communities act as biological buffers against both biotic and abiotic stress, a fact well-documented in recent microbial ecology literature (Zhou et al., 2021). Planting density and mulching strategies also contributed meaningfully to productivity and plant health. The spacing of 1.2 m × 0.8 m ensured optimal root development and minimized competition for sunlight and water. Meanwhile, straw mulching retained 14–18% more soil moisture, suppressed weeds, and improved fruit uniformity. This holistic approach reflects the "integrated crop management" philosophy that is gaining traction globally. One of the underappreciated aspects of pumpkin cultivation is pest and disease resistance. The use of neem extract (a traditional and organic method) achieved a 67% reduction in aphid and melon fly infestations without the use of chemical pesticides. This not only safeguards human and environmental health but also ensures compliance with organic farming standards—opening doors for potential export markets.

The storage qualities of pumpkin also deserve attention. Fruits harvested using improved techniques maintained up to 92% of their vitamin A content after four months of storage. This is important in a region with limited access to year-round fresh produce. Pumpkin's storability also positions it as a strategic food security crop in Karakalpakstan's seasonal food supply system. Analyzing the socio-economic implications, pumpkin cultivation has the potential to create new rural livelihoods. With a relatively short growing cycle (90–120 days) and minimal input requirements, it can be integrated into household-level production, supporting women's participation in agriculture. Additionally, pumpkin-based value chains—processing, seed oil extraction, dried snacks—can offer income diversification in rural economies. Statistical modeling from this study indicated that yield variation was primarily influenced by three factors: irrigation method (34%), organic amendment (27%), and cultivar selection (21%). This suggests that any scaling-up effort should prioritize access to irrigation tools, composting knowledge, and resilient seed varieties. The table below summarizes these contributions:

Factor	Contribution to Yield Variation (%)
Irrigation method	34
Organic fertilization	27
Variety selection	21
Mulching & spacing	12
Pest control method	6

Furthermore, this study sheds light on the importance of local agricultural extension services. Knowledge transfer is often the limiting factor in the adoption of new technologies. For example, farmers unaware of composting or biofertilizer methods are unlikely to apply them correctly. Therefore, investment in farmer education and demonstration plots is critical. It is also necessary to understand the long-term environmental benefits of the discussed technologies. Reduced chemical input and enhanced soil organic matter contribute to the restoration of degraded lands, which is a central goal of Uzbekistan's 2030 agricultural sustainability strategy. This shows that pumpkin cultivation is not only a productivity-focused initiative but also an environmental restoration tool. Another important discussion point is market access. While production improvements are important, without adequate storage, transportation, and market linkages, the economic value remains unrealized. Cold chain infrastructure and farmer cooperatives can play a crucial role in reducing post-harvest losses and ensuring fair pricing. From a policy standpoint, the government of Uzbekistan should consider integrating pumpkin and other arid-compatible crops into state-supported agricultural programs. This includes subsidies for drip irrigation kits, compost bins, neem extract production, and training workshops. Donor organizations can also assist in scaling pilot programs across different regions of Karakalpakstan. Comparing the results of this study with those conducted in other regions (e.g., Turkmenistan, Iran, and Egypt), the trends remain consistent: pumpkins thrive under stress when given strategic inputs. This reaffirms the crop's global resilience and reinforces the urgency of adopting it in climate-vulnerable zones. The potential for research expansion also exists. Future studies could focus on intercropping pumpkin with legumes, developing digital decision-support tools for irrigation scheduling, or experimenting with hydrogel application in saline soils. Interdisciplinary research can further enhance efficiency and profitability. Finally, pumpkin cultivation in Karakalpakstan must be viewed through the lens of climate resilience. With projected temperature increases and further reduction in water availability due to climate change, crops like pumpkin provide a strategic response. Scaling up its cultivation aligns with national adaptation strategies and can help buffer food systems against future volatility.

CONCLUSION

The conducted research on the technology of growing pumpkin (*Cucurbita L*) in the conditions of Karakalpakstan has demonstrated that this crop possesses high potential for widespread and sustainable cultivation in arid and saline-prone environments. Based on the results of field trials, data analysis, and literature synthesis, it can be concluded that pumpkin not only adapts well to the agroecological characteristics of the region but also offers notable advantages in terms of yield, water efficiency, and nutritional value. The study confirmed that local varieties such as

Karakalpak-1 and *Turar* are most suitable for the conditions of Karakalpakstan, outperforming imported cultivars in stress resistance and productivity.

The integration of drip irrigation technology significantly improved water-use efficiency, which is particularly critical in the water-scarce context of Karakalpakstan. This method enabled farmers to reduce water consumption by up to 42% while increasing yields by up to 18%, proving its cost-effectiveness and environmental value. Furthermore, the use of organic compost and biofertilizers played a substantial role in improving soil fertility, reducing salinity, and enhancing overall plant health. These inputs are not only affordable and accessible but also align with the principles of sustainable and ecological agriculture. Mulching techniques, optimal planting density, and biological pest control using neem extract contributed to better crop management and fruit quality. These approaches reduced the need for synthetic chemicals, thereby supporting environmentally safe farming practices and meeting organic agriculture standards. Pumpkins grown under these conditions retained high levels of vitamins A and C after harvest and demonstrated a longer shelf life, which is essential for marketability and food security in the region. The socioeconomic implications of expanding pumpkin cultivation are also promising. Pumpkin farming can contribute to rural employment, particularly among women and smallholder farmers, by providing alternative income sources through cultivation, processing, and marketing. The development of local value chains for pumpkin products can stimulate economic activity and support regional development goals. Additionally, the storage potential of pumpkins makes them a strategic crop for ensuring year-round food supply.

Considering the climatic challenges and ecological degradation facing Karakalpakstan, pumpkin cultivation represents a practical and adaptive solution. Its successful growth under minimal water conditions, combined with its resilience to soil salinity and high temperatures, supports its role as a climate-resilient crop. Policymakers, agricultural agencies, and development organizations are encouraged to promote pumpkin cultivation through targeted training, subsidies for drip irrigation systems, and access to high-quality seeds and organic inputs.

In conclusion, the development and implementation of region-specific agrotechnologies for pumpkin production can transform the agricultural landscape of Karakalpakstan. With continued investment in research, farmer education, and infrastructure, pumpkin can become one of the leading crops contributing to both food security and sustainable land use in the region. The results of this study provide a practical framework for scaling up pumpkin cultivation and serve as a foundation for future innovations in dryland farming systems.

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