Assessing the economic viability and preference dynamics of G1 Garlic in Mianwali: A comparative study of Hybrid and non-Hybrid Varieties.

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DECLARATION

I, **Muhammad Ussairum Abdullah Khan** hereby declare that the research work entitled **'Assessing the economic viability and preference dynamics of G1 Garlic in Mianwali: A comparative study of Hybrid and non-Hybrid Varieties.'** is entirely my own work. The content of this dissertation is original and has not been submitted in whole or in part for consideration for any other degree or qualification in this or any other University. Any materials or information obtained from external sources have been appropriately acknowledged and referenced.

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DEDICATION

I dedicate this work to my supportive family who always believed in me and supported me in each step during the study period.

Assessing the economic viability and preference dynamic of G1 Garlic in Mianwali: A comparative study of Hybrid and non-Hybrid varieties

Abstract

G1 Garlic is a new garlic variety introduced in Pakistan by NARC aimed to boost the production of garlic for Paistan and reduce the garlic imports bill. This variety shows a significant yield than the other available varieties in the country. Small farmers, backbone of Pakistan's agriculture, saw it as an opportunity and adopted it to generate more profit from it however rising seed prices are a big hurdle in thier way. Understanding the economic viability of variety for small farmers and identifying the preferance dynamics of consumers when buying garlic was the main aim of study.The study is located in the district of Mianwali where data from small farmers helps to identify the imapct of changes in seed prices to the profiatbility of the hybrid and non hybrid varietys of Garlic. Apart from seed cost the study helps to recognize other factors that influence farmers profiatbility.Secondly Consumer choice experiment further shows the prefrence dynamic of households when comparing various attributes of these varieties.

Key words : G1 Garlic, Cost of Production , Sensitivity, Consumer Choice ,NARC

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Chapter 1: Introduction

Background:

Pakistan is home to 8.2 million farm families (Agriculture census 2010). These families are primarily responsible for fulfilling the fundamental food and nutritional needs of the estimated population of 231 million individuals residing in the region (*Pakistan | Data,* n.d.). The agricultural industry in Pakistan is a crucial component of the country's economy, as it contributes significantly to the gross domestic product (GDP). According to the Pakistan Economic Survey FY2022, the sector accounts for 22.7% of the country's GDP. Additionally, the agricultural industry is a significant source of employment, providing jobs to approximately 37.4% of the total labour force in Pakistan, as reported by the same survey. The sector's contribution to the economy and employment highlights its importance and underscores the need for continued investment and support to ensure its sustained growth and development. According to the available data, it can be inferred that a significant proportion, specifically 62.56%, of the entire populace of Pakistan is situated in rural regions. These individuals are reliant, either directly or indirectly, on the agricultural sector for their sustenance and livelihood.

At the current time, it can be observed that a significant proportion of agricultural practitioners in Pakistan, specifically 90% or approximately 7.4 million individuals, are classified as smallholder farmers. This classification pertains to those who possess a land area of less than 12.5 acres or 5 hectares. Agriculture is a crucial sector of the Pakistani economy, contributing significantly to the country's GDP. However, most farmers in Pakistan encounter a multitude of obstacles that impede their capacity to generate a sustainable income from their agricultural activities. These challenges may include limited access to modern farming technologies, inadequate irrigation facilities, unpredictable weather patterns, and insufficient financial resources. As a result, many farmers struggle to maintain their livelihoods and provide for their families, despite their critical role in the country's agricultural sector. One of the primary obstacles that impedes agricultural productivity is the insufficient availability of contemporary inputs, credit, and extension services. This lack of access to modern resources hinders the efficiency of agricultural practises, resulting in lower yields and reduced profitability. Furthermore, a multitude of farmers encounter obstacles when attempting to enter markets that offer equitable compensation for their agricultural yield. Additionally, inadequate infrastructure, such as insufficient storage and transportation amenities, poses a

significant hindrance to their success. In addition to the inherent risks associated with agricultural production, farmers are also confronted with the challenge of coping with unpredictable weather patterns, which can result in devastating consequences such as floods and droughts. These extreme weather events can inflict significant losses upon farmers, thereby impeding their ability to maintain their livelihoods and sustain their agricultural operations. The concept of "livelihood" encompasses a diverse array of resources, competencies, and activities that are essential for the maintenance and continuation of a particular mode of existence. This multifaceted construct encompasses not only the material and economic resources necessary for subsistence, but also the social and cultural practises, knowledge systems, and ecological relationships that underpin and sustain human communities. In essence, livelihood refers to the complex web of interdependent factors that enable individuals and groups to meet their basic needs, pursue their aspirations, and maintain their well-being over time. As per the scholarly work of de Haan & Zoomers, (2005), the concept of livelihood encompasses an array of resources and activities that individuals employ to maintain their existence. These may include economic pursuits, social interactions, and the utilisation of natural resources. It is a multidimensional construct that is integral to the survival and well-being of individuals and communities alike. In accordance with Chambers & Conway, (1992) scholarly work, the concept of livelihood is defined as a Multifaceted model that encompasses an individual's diverse range of capabilities, assets, and activities, all of which are essential for their sustained survival and well-being over an extended period of time. The livelihood of an individual encompasses various interrelated components, including but not limited to income, health, education, and social networks. These components are critical determinants of an individual's well-being and are intricately linked to one another. Income, for instance, is a crucial aspect of livelihood that enables individuals to access basic needs such as food, shelter, and clothing. Health, on the other hand, is a fundamental component that influences an individual's ability to engage in productive activities and achieve their full potential. Education is also a vital aspect of livelihood that enhances an individual's knowledge and skills, thereby increasing their employability and earning potential. Finally, social networks play a critical role in shaping an individual's opportunities and access to resources, including employment opportunities, social support, and information. In summary, the various components of livelihood are interdependent and play a crucial role in shaping an individual's overall well-being.

The agricultural sector in Pakistan is comprised of a significant number of small farmers, who encounter a multitude of challenges that have a detrimental effect on their means of subsistence. Small-scale farmers in Pakistan are faced with a multitude of challenges that impede their agricultural productivity and profitability. These challenges include but are not limited to inadequate availability and accessibility of agricultural inputs, restricted market access, and suboptimal crop prices. These factors collectively contribute to the overall vulnerability of small farmers in Pakistan, thereby hindering their ability to achieve sustainable livelihoods and economic growth. The presence of various impediments poses a significant challenge to the productivity and profitability of small-scale farmers, thereby impeding their ability to maintain their livelihoods.

The benefits they receive from the agricultural market economy are marginal. In light of the various obstacles faced by farmers, a considerable number of them are actively seeking out viable strategies to transform their farm assets into more lucrative investment opportunities. In the present day, certain agriculturists are delving into alternative sources of revenue generation that do not involve traditional farming practises. These alternative activities include the rearing of livestock, the creation of handicrafts, and the establishment of small-scale commercial enterprises. There are individuals who aim to enhance their agricultural revenue by implementing novel technological advancements, broadening the range of crops they cultivate, or allocating resources towards the cultivation of high-value crops. Agriculturalists who operate on a small scale exert significant effort to produce substantial income from their agricultural resources, given the chance. The individuals in question exhibit a persistent inclination towards identifying and capitalising on prospects to leverage their agricultural resources, with the ultimate goal of augmenting their financial gains and enhancing their overall quality of life. The agricultural sector is a vital component of a nation's economy, and the contribution of small-scale farmers to this sector cannot be overstated. The small farmers' involvement in agriculture and their contribution to the Gross Domestic Product (GDP) underscores the importance of the government's role in ensuring that farmers remain interested in their on-farm activities. The government must take proactive measures to provide small farmers with opportunities to increase their profits and enhance their livelihoods. Failure to do so could have far-reaching consequences for the agricultural sector and the economy.

Development Of NARC G1 Garlic :

In Pakistan, there exist government organisations that are dedicated to the advancement of agriculture, such as the Pakistan Agriculture Research Council (PARC). These entities are responsible for formulating policies that are aimed at enhancing the quality of life of small-scale farmers. This is achieved by creating diverse investment opportunities that enable farmers to maximise their profits. The Pakistan Agricultural Research Council (PARC) has initiated a comprehensive research programme aimed at enhancing the productivity of vegetable crops in order to bolster the nation's food security. The programme is designed to investigate and develop innovative techniques and technologies that can be employed to optimise the growth and yield of vegetable crops, thereby increasing their overall production. The ultimate goal of this research initiative is to ensure that the country's food supply remains stable and secure, particularly in the face of potential challenges such as climate change and population growth. The primary objective of the programme was to develop novel variety of vegetables that exhibit resistance to a wide range of diseases, possess high yield potential, and demonstrate adaptability to diverse climatic conditions. The research endeavour was directed towards enhancing the cultivation of vegetable crops and devising effective marketing strategies with the ultimate goal of augmenting profitability and ameliorating the standard of living of small-scale farmers.

The primary objective of the aforementioned programme was to undertake research and development activities aimed at enhancing the yield potential of Garlic crop, with the ultimate goal of producing a high-yield variety. This initiative was reported by The Nation (2020) as a significant domain of the programme. The proposed investigation aims to conduct a comprehensive analysis of the economic viability of cultivating NARC G1 Garlic, a product of the programme under consideration, for small-scale farmers. The study seeks to determine whether investing in this crop is a prudent decision for small farmers to enhance their financial returns and overall standard of living.

Garlic (*Allium Sativum*):

A species of the onion family Alliaceae, garlic is formally referred to as Allium sativum. It is a perennial herb that has been cultivated for millennia and utilised by diverse cultures for medicinal and culinary purposes. Garlic, scientifically known as Allium sativum, is a commonly utilised culinary ingredient that is renowned for its pungent and distinctive flavour

profile. It is a species in the onion genus, Allium, and is native to Central Asia and north-eastern Iran. Garlic is a bulbous plant that belongs to the family Amaryllidaceae, and it has been cultivated for thousands of years for both culinary and medicinal purposes. Its unique flavour and aroma are attributed to the presence of sulphur-containing compounds, such as allicin, which are released when the garlic is crushed or chopped. Due to its versatility and widespread use in various cuisines, garlic has become an essential ingredient in many households and restaurants worldwide. Throughout history, garlic has been widely recognised for its medicinal properties and has been utilised in traditional medicine to treat a diverse range of health conditions. Among the ailments that garlic has been historically employed to address are respiratory infections, digestive disorders, and cardiovascular disease. The therapeutic effects of garlic are believed to be attributed to its rich content of bioactive compounds, such as allicin, which has been shown to possess potent antimicrobial, anti-inflammatory, and antioxidant properties. Furthermore, garlic has been found to exhibit beneficial effects on blood pressure, cholesterol levels, and platelet aggregation, which are all key factors in the development and progression of cardiovascular disease. Throughout history, garlic has been recognised for its medicinal properties and has been utilised as a topical treatment for various skin infections and wounds. The antimicrobial and anti-inflammatory properties of garlic have been shown to be effective in combating a wide range of bacterial, fungal, and viral infections. Additionally, garlic has been found to promote wound healing by stimulating the production of collagen and enhancing blood flow to the affected area. As such, the topical application of garlic has been a popular and effective natural remedy for skin ailments.

Allium sativum, commonly known as garlic, is a fundamental component of the daily dietary intake in Pakistan and is extensively utilised in each province of the country. Garlic is a species in the onion genus, Allium, and is a bulbous plant that belongs to the Amaryllidaceae family. Its consumption has been associated with numerous health benefits, including anti-inflammatory, antioxidant, and antimicrobial properties. The use of garlic in Pakistani cuisine is deeply rooted in the country's cultural heritage and has been passed down from generation to generation. The pungent taste of a commonly consumed food item in Pakistan is known to sweeten upon cooking and is a daily staple for a majority of the population. The agricultural landscape of Pakistan is characterised by the widespread cultivation of garlic, an herbaceous plant belonging to the Allium genus. This crop is grown across all provinces of the country, with particular emphasis on the regions of Punjab and Khyber Pakhtunkhwa, which are

recognised as the primary contributors to the national production of garlic. Currently grown varieties in Pakistan include Lehsun Gulab (Pink Garlic) Chinese variety of Garlic grown locally and the italic Garlic. The local variety known as Lehsun Gulab has gained significant popularity among the population. This variety is highly esteemed for its unique characteristics and is widely recognised for its exceptional quality. Its distinct features have made it a preferred choice among consumers, and it has become a staple in the local market. However, the yield per acre for this variety is quite low as compared to other varieties.

Notwithstanding the domestic production of garlic in Pakistan, the extant yield is insufficient to satiate the growing demand for this pungent herbaceous plant. Consequently, Pakistan resorts to importing garlic from the neighbouring countries of China and Iran to bridge the shortfall in the domestic supply. In order to decrease the reliance on imported garlic, the country of Pakistan has been actively engaged in the development and cultivation of diverse high-yield strains of Allium sativum, commonly known as garlic. This endeavour involves the application of scientific principles and techniques to enhance the productivity and quality of garlic crops, thereby increasing the domestic supply and reducing the need for imports.

NARC G1 Garlic:

The agricultural sector of Pakistan has been facing a challenge of low yield in crops, particularly in the case of a specific variety. In order to address this issue, the Pakistan Agriculture Research Council has undertaken the task of developing a new and improved variety that can provide a higher yield per acre. The process of developing this new variety involves extensive research and experimentation, which includes the identification of suitable genetic traits and the implementation of advanced breeding techniques. The goal of this endeavour is to enhance the productivity of the agricultural sector and contribute to the overall economic growth of the country. The National Agriculture Research Council, a renowned institution in the field of agricultural research, has successfully developed a novel variety of garlic, which has been christened as NARC G1 Garlic. This new variety is expected to revolutionise the garlic industry owing to its unique characteristics and properties. The development of this variety is a result of extensive research and experimentation conducted by the council's team of experts, who have employed cutting-edge techniques and me According to the claim made, the newly developed variety is expected to have a significantly higher yield compared to existing varieties. This could potentially lead to a reduction in the import burden of the country, as it may be able to meet its domestic

demand for this crop. Upon its introduction to the public, farmers endeavoured to cultivate this variety and subsequently reported a significantly higher yield in comparison to the Lehsan Gulab variety. The agricultural producers engaged in the cultivation of crops have successfully traded their yield to the National Agricultural Research Centre (NARC) and other relevant entities at a significantly elevated market value. The surge in demand for the seed can be attributed to its exceptional productivity. However, the limited availability of said seed has led to a significant escalation in its market value. Despite the potential risks associated with the cultivation of this variety, a number of farmers remain motivated to continue its cultivation in order to maximise their financial gains. The implementation of the G1 Garlic variety has garnered significant interest from farmers in Punjab and Khyber Pakhtunkhwa provinces of Pakistan, who are anticipating a substantial increase in crop yield and profitability. This particular variety of garlic has been specifically developed and cultivated to possess desirable traits that are conducive to optimal growth and productivity in the region's agricultural landscape. As such, farmers are eagerly adopting this variety in the hopes of achieving greater success in their farming endeavours.

Research Objectives:

1. Compare the profitability of Garlic varieties using Cost of Production Analysis.
2. To investigate relationship of seed prices of G1 Garlic to its productivity for the small farmers.
3. Identify preference dynamic of household towards the new variety.

Chapter 2: Literature Review

Garlic, scientifically known as *Allium sativum*, is an herb belonging to the family *Alliaceae*. It is closely related to onions, chives, and leeks. The herb is used widely worldwide as a spice or for seasoning in different cuisines. Garlic is planted twice a year, in the spring and in the autumn. Garlic winter does not produce bloom stalks when planted in autumn. It hibernates in the winter and awakens in the spring. In contrast, spring garlic is grown in the spring. Winter variations produce larger heads and mature much sooner than spring kinds. They can grow to be up to 120 cm tall, with bulbs weighing up to 280 g.(*Home - NARC G1 Garlic,* n.d.)Garlic is a plant that can grow at temperatures as low as 3 degrees Celsius. It requires sun exposure for healthy development, yet it can be planted in the shade. It has a weak root system for a one-year plant. This results in high soil and water demands. Garlic requires moist, warm soil that is rich in humus and nutrients. A neutral ground with a pH of about 6.8 is ideal for its development.(*Home - NARC G1 Garlic,* n.d.)

The use of garlic as a medicinal herb dates back to ancient times, and it has been widely recognized for its therapeutic properties. In recent years, there has been a growing interest in the potential health benefits of garlic, particularly in the prevention and treatment of cardiovascular diseases. Amagase (2021) highlights the clinical significance of garlic, emphasizing its richness in allicin, a sulfur-containing compound that is believed to be responsible for its immune-boosting and cardiovascular protective effects. Furthermore, garlic has been found to have a beneficial effect on blood pressure and cholesterol levels, both of which are major risk factors for heart disease. Study conducted by (Wolde et al., 2018) found that garlic extract exhibited potent antibacterial activity against various pathogenic bacteria, including Staphylococcus aureus and Escherichia coli. Similarly, a study by (Bayan, Koulivand, & Gorji, 2013) reported that garlic supplementation was effective in reducing inflammation and oxidative stress in individuals with metabolic syndrome. Moreover, garlic has been shown to possess immunomodulatory properties, which may help boost the immune system and protect against various diseases. A study by (Arreola, et al., 2015) reported that garlic supplementation was effective in enhancing the activity of natural killer cells, which play a crucial role in the immune response against cancer and viral infections.A study conducted by (Ried et al., 2012) examined the effect of garlic supplementation on systolic blood pressure in individuals with high blood pressure. The study found that garlic supplementation resulted in a significant reduction in systolic blood

pressure, with an average decrease of 7.7 mm Hg. This finding is significant as it suggests that garlic supplementation may be a viable option for individuals with hypertension who are seeking alternative or complementary therapies to manage their blood pressure. One area of research that has received particular attention is the anti-cancer properties of garlic. In a study conducted by (Fleischauer & Arab, 2001), it was found that regular consumption of garlic was associated with a lower risk of developing several types of cancer, including colon, stomach, and prostate cancer. The study's findings suggest that garlic may have chemo preventive effects, which could be attributed to its high content of organosulfur compounds. These compounds have been shown to have anti-cancer properties by inhibiting the growth and proliferation of cancer cells, inducing apoptosis, and preventing DNA damage.(Ankri & Mirelman, 1999) have conducted research on the antimicrobial properties of garlic and have found that it possesses the potential to enhance the immune system. Additionally, garlic has been shown to have antioxidant properties, which can help to protect the body from oxidative damage caused by free radicals. Overall, the research conducted by Ankri and Mirelman (1999) suggests that garlic has the potential to be a valuable natural remedy for enhancing the immune system and preventing infectious diseases. One of the most notable benefits is its anti-inflammatory properties, which have been extensively studied in recent years. Inflammation is a natural response of the body to injury or infection, but chronic inflammation can lead to various health problems, including osteoarthritis. Osteoarthritis is a degenerative joint disease that affects millions of people worldwide and is characterized by inflammation and pain in the joints. Studies have shown that garlic can aid in the reduction of inflammation in the body, making it a potential treatment for conditions such as osteoarthritis (Funk et al., 2016). The anti-inflammatory properties of garlic are attributed to its active compounds, including allicin, diallyl disulfide, and S-allyl cysteine. These compounds have been found to inhibit the production of pro-inflammatory cytokines and enzymes, which are responsible for the inflammatory response in the body. In addition to its anti-inflammatory properties, garlic has also been found to possess antioxidant, antimicrobial, and anticancer properties. In recent years, there has been a growing interest in the use of natural remedies for the treatment of various ailments. One such remedy that has gained attention is garlic, which has been used for centuries for its medicinal properties. In a study conducted by (Weber et al., 1992), the authors investigated the potential of garlic as a topical treatment for skin infections and wounds. The study found that garlic has antimicrobial activity against several strains of bacteria that cause skin infections, making it a promising natural remedy for such

conditions. The use of garlic as a topical treatment for skin infections and wounds has been documented in traditional medicine practices for centuries, and the findings of this study provide scientific evidence to support its effectiveness.

Pakistan is ranked 18th in garlic production worldwide, contributing 0.31% of total world production (Tridge, 2022). The graph (Figure 1) depicts the trend in garlic output in Pakistan from 2017 to 2021. According to the data, the country's garlic production has been increasing, albeit with volatility. Garlic production was 75 metric tonnes in 2017, and grew to 81.17 metric tonnes in 2018, representing an 8.23% increase. However, production fell significantly to 75.34 metric tonnes in 2019, representing a 7.14% reduction. Garlic production in Pakistan climbed to 85.64 metric tonnes in 2020, representing a 13.73% increase over 2019.The most striking trend in the statistics is the considerable increase in garlic output in Pakistan in 2021, with 127.477 metric tonnes produced, representing a 48.8% increase over the previous year.

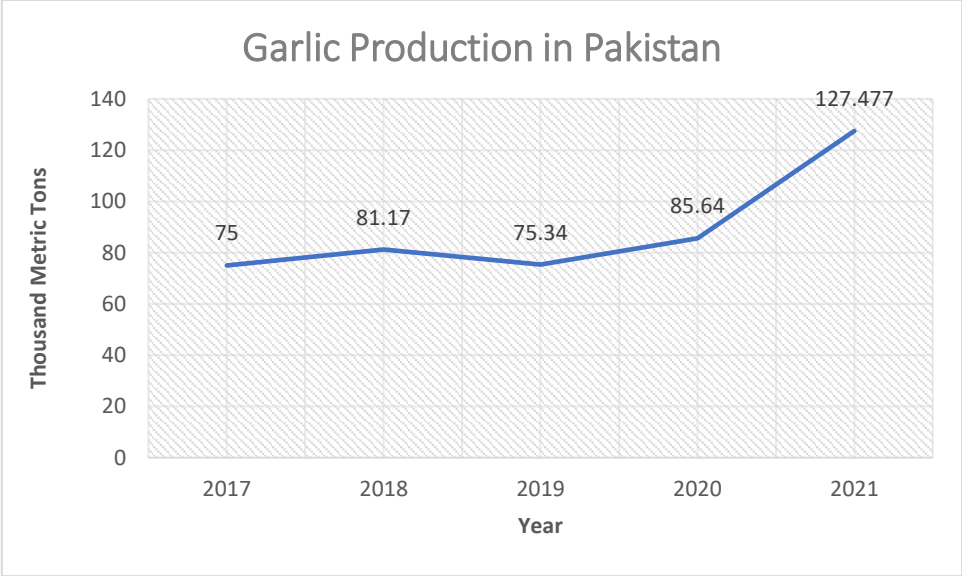

Figure 1 Garlic Production In Pakistan (2017-2021)

Garlic is cultivated on 13383 hectares, primarily in Punjab (7863 hectares) and Khyber Pakhtunkhwa (3500 hectares), with a production volume of 127477 tonnes overall (Fruits Vegetables and Condiments statistics of Pakistan, 2020-2021). According to Figure 2, Punjab is Pakistan's greatest garlic-producing province, accounting for 57% of total garlic production in the country. Punjab produced 72,834 metric tonnes of garlic in the same year. Khyber Pakhtunkhwa (KPK) is Pakistan's second-largest garlic-producing province, accounting for

31% of total garlic production. KPK produced 39,500 metric tonnes of garlic in 2021. Baluchistan, on the other hand, is Pakistan's third-largest garlic-producing province, accounting for 9% of overall garlic production. Baluchistan produced 11,203 metric tonnes of garlic in 2021.However, the province has the potential for future increase in garlic production if farmers are provided with enough support in the form of irrigation facilities, loans, and the use of modern farming techniques. Sindh is Pakistan's least garlic-producing province, accounting for only 3% of overall garlic production. Sindh produced 3,940 metric tonnes of garlic in 2021. Sindh's low output could be ascribed to unfavourable weather conditions.

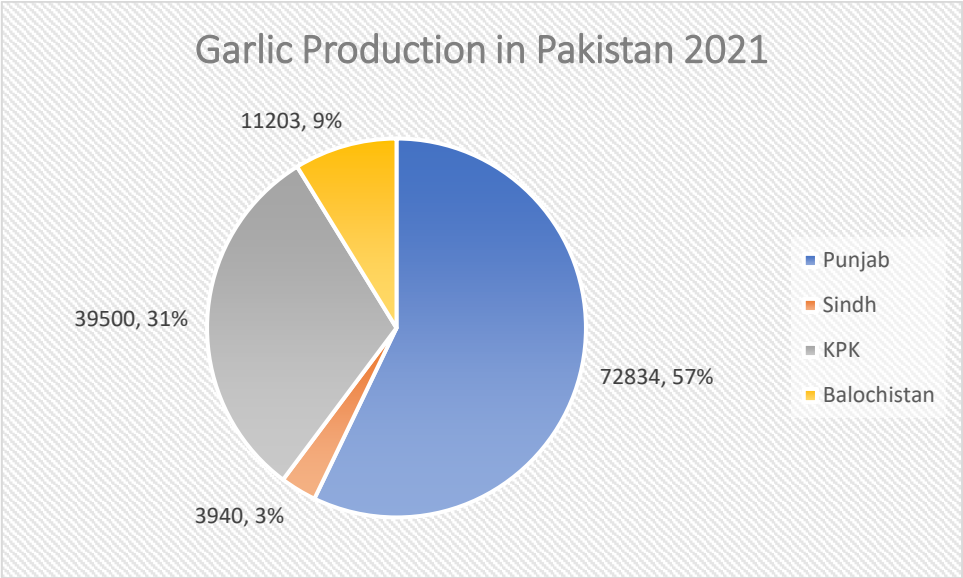

Figure 2 Contribution of each Province in Garlic Production 2021

Pakistan, at this point, is consuming one locally developed variety Named 'Leshun Gulabi' / Pink Garlic or Desi Garlic but it has a meagre yield per acre. Other varaities cultivated are the chinese and italian garlic. Surprisingly, due to conducive Agro-climatic conditions, Pakistan’s yield (tonnes per acre) is higher than that of India and Bangladesh, the second and third world’s largest garlic producers, respectively. However, the Production is still insufficient to cover the local demand for Garlic.

Over the last five years, Pakistan's garlic imports have fluctuated dramatically. The country imported garlic worth 68.03 million USD in 2017, the largest import value during this time period. However, the import value fell by nearly 50% to 36.19 million USD in 2018.

The import value climbed to 57.81 million USD in 2019, yet it remained much lower than the import value in 2017 (Figure 3). The year 2020 had a significant increase in garlic imports,

with a value of 102.36 million USD, the most in the five-year period. However, the import value fell to 68.54 million USD in 2021, which is still greater than the import value in 2018 but lower than the import values in 2017 and 2020. Overall, the data reveals that over the last five years, Pakistan's garlic imports have been volatile and subject to large swings, with import amounts ranging from 36.19 million USD in 2018 to 102.36 million USD in 2020.

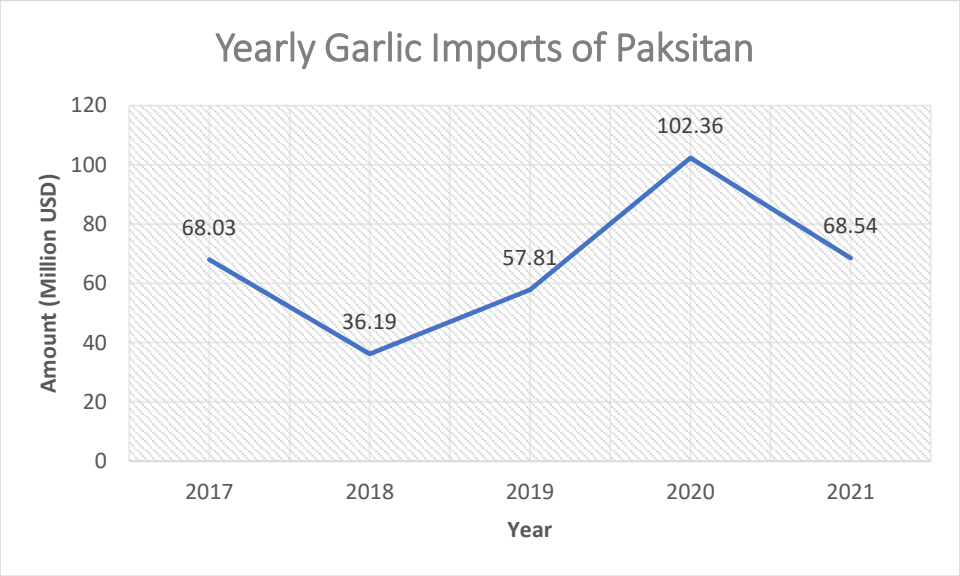

Figure 3 Garlic Imports of Pakistan (2017-2021)

In 2017, and 2018, the import volume remained relatively stable at around 37 thousand metric tonnes (Figure 4). However, there was a substantial increase in import volume in 2019 to 58.15 thousand metric tonnes, representing a 55% increase over the previous year. The import volume increased dramatically in 2020, peaking at 101.05 thousand metric tonnes, about doubling the import volume in 2019. However, import volume fell drastically in 2021, falling to 61.72 thousand metric tonnes, a 39% decrease from the previous year. Overall, the trend in garlic import volume in Pakistan shows a significant increase from 2017 to 2020, followed by a sharp decline in 2021(Figure 4). This suggests that the demand for garlic in Pakistan was growing during this period, but the trend has reversed in the recent year. Pakistan's local Production of Garlic meets only two-thirds of its domestic needs. For that reason, Pakistan imported 61.72 metric tonnes of Garlic worth $68.54 million (Rs11 billion) in 2021, whereas the import value was even higher in 2020, standing at $102m, according to International Trade Centre data. That is the reason Pakistan is 10th ranked in garlic imports (Tridge, 2022).

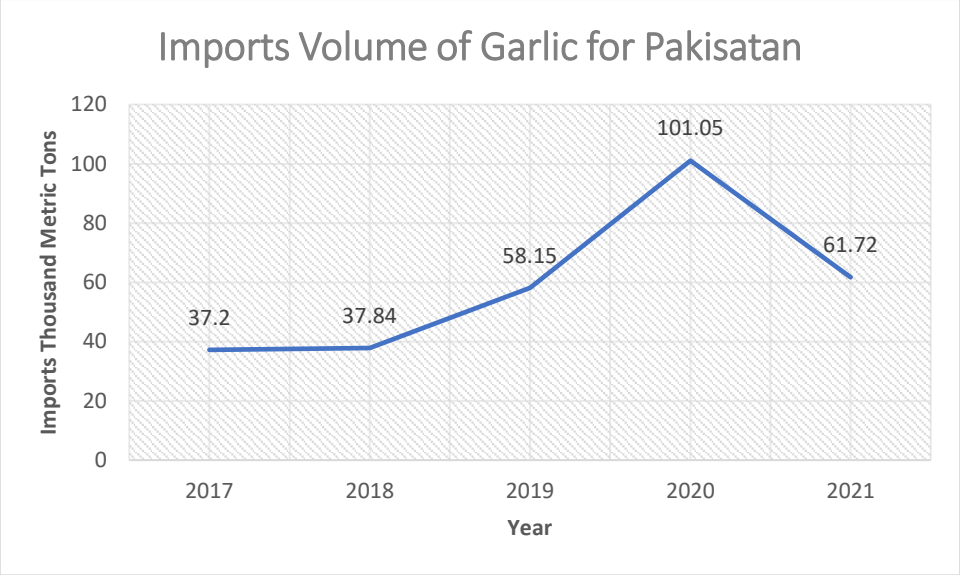

Figure 4 Garlic Imports Volume Pakistan (2017-2021)

China was the most significant contributor to garlic imports in 2021, with a share of 98% and a total worth of 67.8 M USD. With Iran contributing to 1.56% and Afghanistan, Thailand, and Brazil contributing to the remaining 0.46% shares (Tridge, 2022).

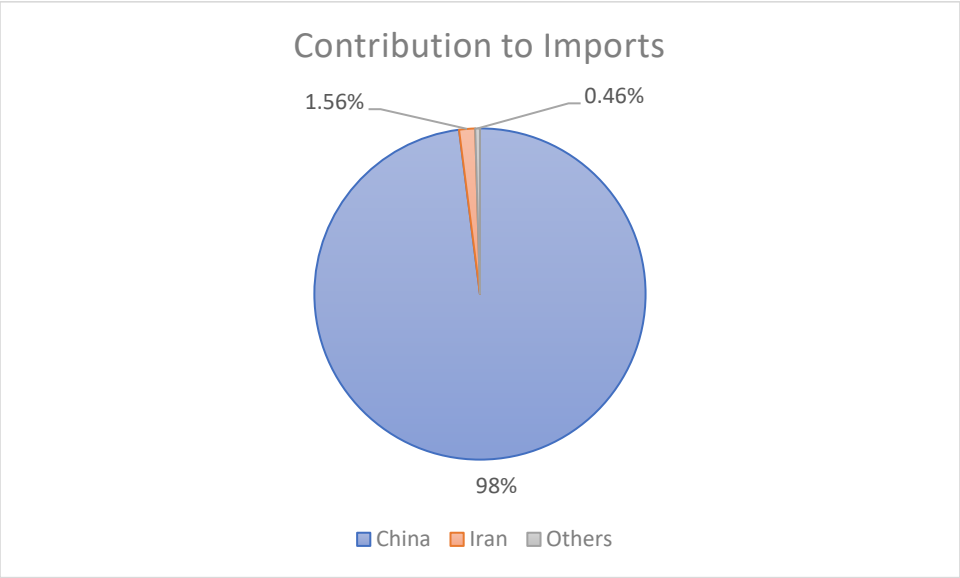

Figure 5 Countries Contributing to Garlic Imports

In comparison, according to Figure 6 In 2017, the value of Pakistan's garlic exports was 2.26 million USD, however that figure decreased dramatically in 2018 to 0.73 million USD. However, the value of garlic exports grew in 2019 to 1.01 million USD, demonstrating a return from the previous year's drop. The value of garlic exports climbed to 2.09 million USD

in 2020, more than doubling the value of garlic exports in 2019. This increase in export value can be ascribed to increased garlic output in Pakistan as well as increasing international demand for Pakistani garlic. However, the value of garlic exports fell to 1.7 million USD in 2021, an 18.7% fall from the previous year. Overall, the trend in Pakistani garlic exports reveals a variable pattern, with export values ranging dramatically from year to year. While there has been some improvement in export value in recent years, the trend for Pakistani garlic in the export market is not as steady as the trend in the import market.

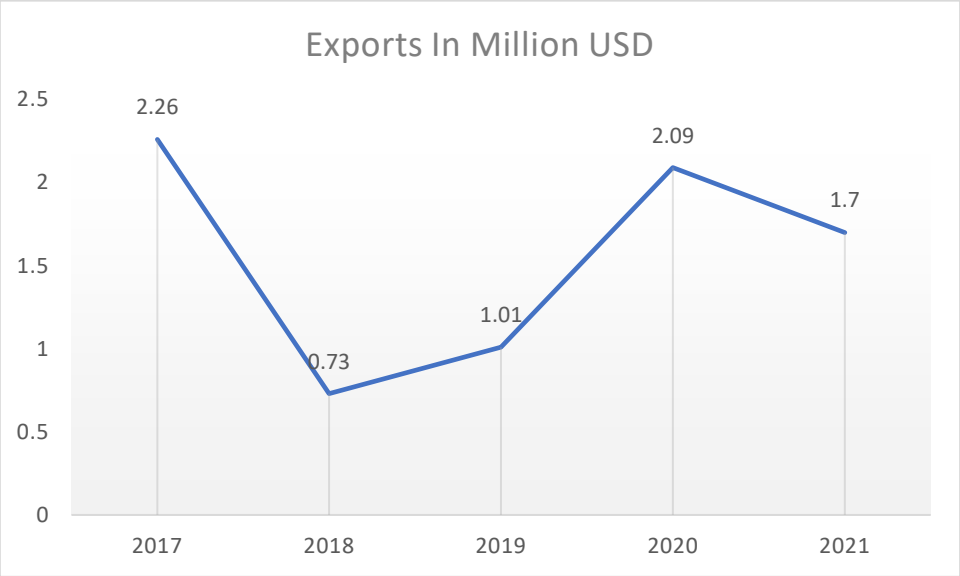

Figure 6 Garlic Exports for Pakistan in Million USD (2017-2021)

Garlic exports from Pakistan totalled 1.49 metric tonnes in 2017 but fell dramatically to 0.526 metric tonnes in 2018 (Figure 7). However, garlic exports grew again in 2019 to 0.591 metric tonnes, demonstrating a comeback from the previous year's drop.

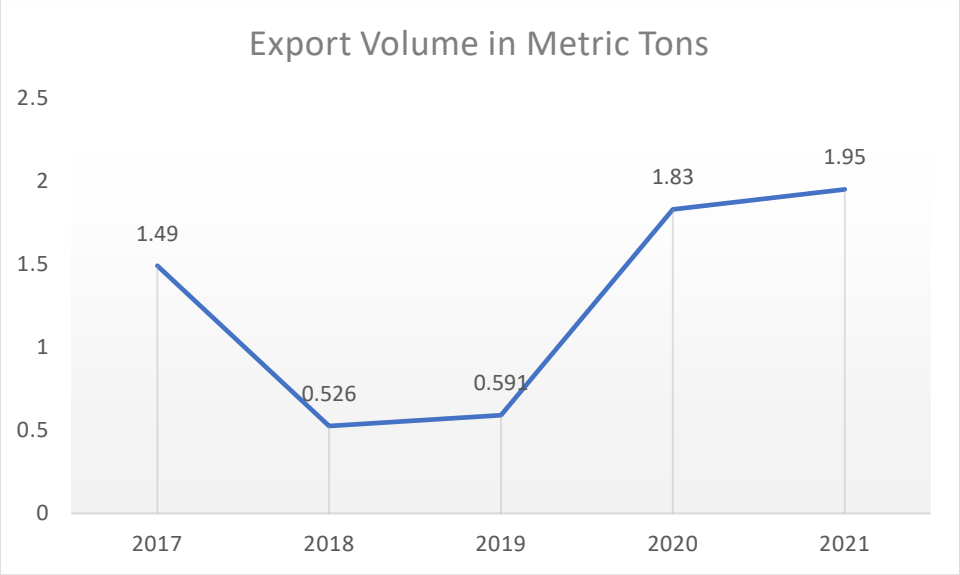

Figure 7 Garlic Exports for Pakistan in Metric Tons (2017-2021)

The volume of garlic exports climbed dramatically in 2020, reaching 1.83 metric tonnes, more than three times the volume of garlic exports in 2019. This increase in export volume can be ascribed to increased garlic production in Pakistan as well as rising international demand for Pakistani garlic.

In 2021, the volume of garlic exports increased marginally to 1.95 metric tonnes, continuing the trend. Overall, the trajectory of Pakistani garlic export volume reveals a shifting pattern, with export volumes ranging dramatically from year to year. While export volume has increased in recent years, the trend in the export market for Pakistani garlic is not as steady as the development in the import market. Pakistan was ranked 30th, contributing to just 0.05% of total global exports of Garlic. Sri Lanka was the biggest export destination of Garlic, with 65% of total export numbers in 2021 (Tridge, 2022). Afghanistan contributing to 12%, UAE with 7% shares in the exports. Saudi Arabia, Qatar and UK contributing to 4%, 3% and 2% shares respectively. USA, Canada, Malaysia, Bahrain, Uzbekistan and Hong Kong make the remaining 7% of the export shares (Figure 8).

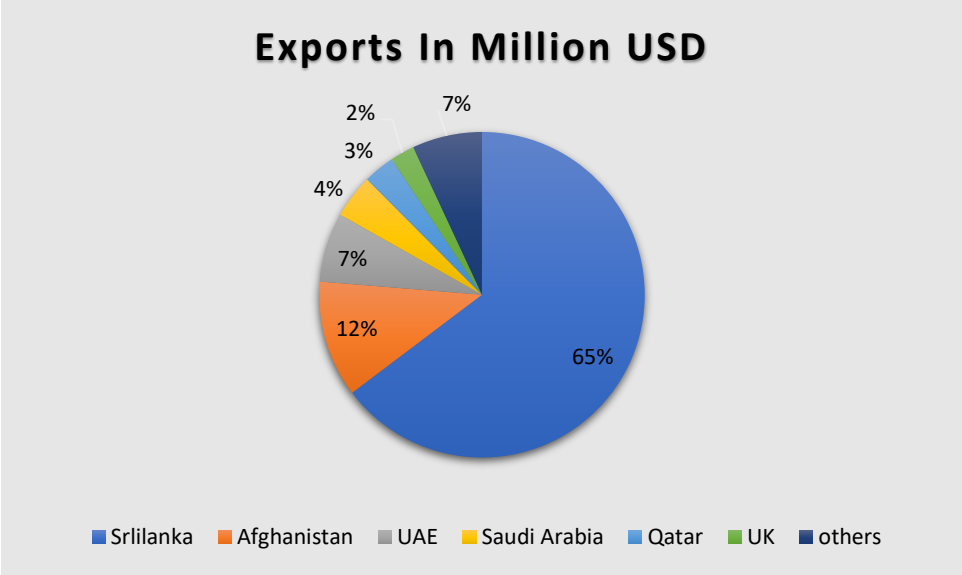

Figure 8 Countries contributiong to Garlic Exports of Pakistan

Pakistan Agricultural Research Council (PARC), under The Vegetable Crop Research Programme of the Horticulture Research Institute, started garlic variety development in 2009-10 to achieve a high-yielding variety for the country. Under this program, a team of scientists led by Dr. Humayun of the National Agricultural Research Centre (NARC) developed a variety named NARC G1 Garlic which supposedly had an excellent capability to show higher yield than other local varieties. The new variety was presented to and approved by the Variety evaluation committee of agricultural research in a NARC Meeting on July 11, 2018. It was also Vetted by the Seed council of Punjab and KPK in June 2018 (The Nation, 2020).

It showed high yield capability in comparison to desi Garlic. Its yield was around 200 to 250 Maund per acre, while the pink Garlic had a yield capacity of around 70 to 80 Maund per acre (The Nation, 2022).

New Variety showed better medicinal properties than the pink one and had a high amount of allicin, contributing to the human immune system. Allicin, one of the most important bioactive compounds, is derived considerably from alliin. For humans, allicin possesses a unique therapeutic role; however, the Production of allicin in Garlic is the result of a defence response to harmful external stimuli such as crushing, cutting, grinding, and heating (Shamshad et al., 2022) The NARC-G1 is regarded as the best kind of garlic in Pakistan, with a single bulb weighing between 250 and 400 grammes, compared to 30 to 50 grammes for locally grown garlic bulbs (The Nation, 2020).

The variety was introduced via Station Trials and National Uniform Yield Trials nationwide. Impressive Results showed high productivity across the country. Seeds were then made available through NARC and locally by farmer-to-farmer trade (Ahmed, 2020). According to (Hanif, 2021), G1 Seed was stolen from Narc and sold in the market at high prices. The variety is now Cultivated All across the Country. The cultivation process starts in October and is longer than traditional pink Garlic, and then the crop is harvested in June. Farmers across Pakistan showed massive interest in the variety, and it was adopted as a potential cash crop across many provinces of Punjab and KPK (Ahmed, 2020). NARC Due to being in early introduction stages, it was not presented to the market as a food crop but only sold as seed by NARC and after the first cultivation and harvesting cycle by NARC and Farmer to Farmer sales. During the early stages price of the seed was around Rs 2000 to 2500 per Kg (The Nation, 2020), but after the first cycle, it went high due to high demand and low supply to around 8000/kg; This resulted in high profits for the early cultivators of the crop. It became the talk of the town in various districts of Punjab as well as KPK.

Various firms, besides selling seeds, are providing consultancy services to farmers regarding plantation harvesting storage and planning of this variety. Breeders are facing high seed demand from various pharmaceutical and food processing companies. Belarus has shown interest in import of this variety as well. A NARC official in an interview stated that they are working on making this variety an exportable product (The Nation, 2020).

The choice experiment (CE) is a widely employed research methodology that aims to explore and analyse consumer preferences for both market and non-market products. This method was initially developed by Louviere and Hensher in 1983, and later expanded upon by Louviere and Woodworth in the same year. By utilizing the CE approach, researchers are able to gain valuable insights into the decision-making processes of consumers, allowing for a deeper understanding of their preferences and choices. The theoretical framework employed in this study is based on Lancaster's consumer theory, which was introduced in 1966. According to this approach, it is posited that consumers derive their utility not directly from the product itself, but rather from the specific attributes that the product possesses. The majority of consumer engagement (CE) studies conducted in the field of agri-food pertain to the exploration of new product development, as evidenced by the works of Zhu et al. (2018) and Wanyama et al. (2019). These studies delve into the various aspects of creating novel products within the agri-food sector, examining factors such as consumer preferences, market

demand, and technological advancements. Additionally, CE research in agri-food encompasses investigations into effective marketing strategies. Scholars such as Casini et al. (2016) and Wu et al. (2017) have contributed to this area of study by examining the impact of different marketing approaches on consumer engagement. These studies delve into the intricacies of consumer behavior, market segmentation, and promotional techniques, providing valuable insights for agri-food businesses seeking to optimize their marketing efforts. Furthermore, CE studies in the agri-food domain extend to the realm of policy recommendations. Researchers such as De Marchi et al. (2019) and Ballco et al. (2020) have focused their efforts on analyzing the implications of various policies on consumer engagement within the agri-food sector. These studies explore the regulatory landscape, government interventions, and industry standards, aiming to provide evidence-based recommendations for policymakers and stakeholders in the agri-food industry. In summary, the field of agri-food CE research encompasses a wide range of topics, including new product development, marketing strategies, and policy recommendations. These studies contribute to the advancement of knowledge in the agri-food sector, offering valuable insights for industry practitioners, policymakers, and researchers alike. The food industry is confronted with a potential market failure risk when introducing a new product, as the level of food innovation often falls short in meeting customer satisfaction (Horvat et al., 2019; Guiné et al., 2020). This implies that there is a significant challenge in developing novel food products that truly resonate with consumers and fulfill their expectations. The elucidation of consumer preferences pertaining to the various attributes of a product holds paramount importance for stakeholders engaged in the process of strategic decision-making (Dawoud, 2019). In addition, it is crucial to acknowledge that food policies face the potential challenge of ineffectiveness and frequently suffer from inadequate targeting, as highlighted by Guo et al. (2019) in their research findings.

Chapter 3: Methodology

This Study is divided into two phases, first phase would deal with the first two objective and area selected for data collection is District Mianwali as the district has seen immense increase in garlic cultivation in past year and is following an increasing trend. Many Farmers are investing heavily in the new Garlic variety. The second phase would deal with the second objective and the data would be collected from various sectors of Islamabad having supermarkets, Sabzi mandi's and local vendor shops as well. The reason for selection of Islamabad as data collection area is the availability of respondents from various cultural economic and social background like international residents, working class customers, labours etc.

Phase 1:

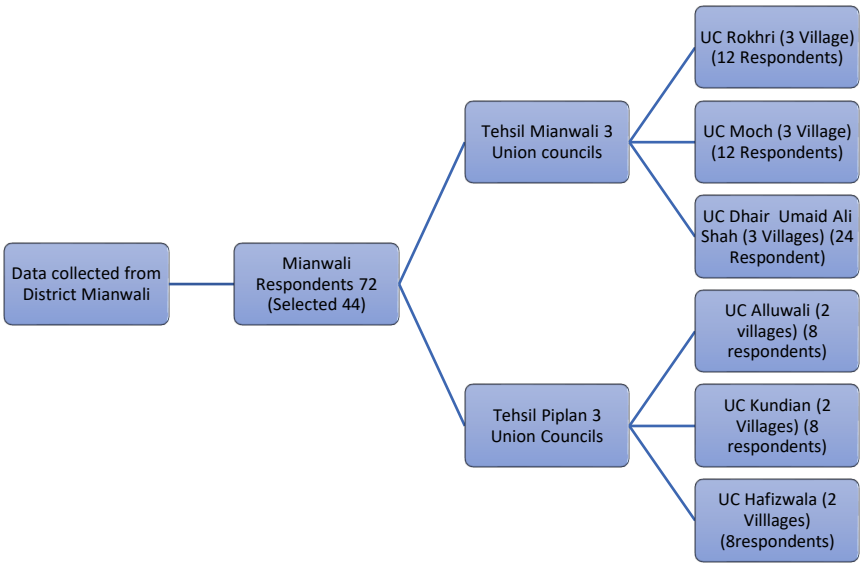

Figure 9 Sampling Scheme

During the First Phase major G1 Garlic growing Union Councils were selected with the consultation of Department of Agricultural Extension in Mianwali District. A total of 72 farmers were selected using random sampling method from 2 Tehsils of District Mianwali Tehsil Piplan ans Tehsil Mianwali. From tehsil Mianwali 3 major Garlic producing Union councils were selected.From each union council 3 villages were selectd randomly. Each village had a representation of 4 respondents except for the villages of union council Dhair Umaid Ali, which had 8 respondents from each village. Reason being the Union council being the major contributor of G1 Garlic cultivation.From Tehsil Piplan also 3

UC's were selected each Union council had 2 random villages represecting it. From each village 4 farmers were randomly selected for the interview. A well structured comprehensive interviews were conducted for the collection of detailed information on various aspects of G1 Garlic crop. Interview data contain information on socio-economic characteristics of the farmers, source of irrigation, management practices, and input-output quantities. After thorough study 44 interviews of respondents were selected for analysis because remaining lacked information or on counter checking information provided by respondents was wrong. For economic analysis cost of production of G1 was identified using various cost components. Profitability of the hybrid and non hybrid crop was calculated by cost of production and identifying total net profit and calculating Net profit margin, and Return on Investment.

Net Profit Margin = (Total Revenue - Total Cost of Goods Sold) / Total Revenue x 100%

Equation 1

ROI = (Total Revenue - Total Cost of Production) / Total Cost of Production x 100%

Equation 2

Variable	Description
Age	Age of the farmer
Gender	Gender of the farmer
Education	Highest level of education attained by the farmer
Farm size	Total land area used for garlic cultivation by the farmer
Land Associated with Garlic	Total land used for Garlic cultivation
Garlic production experience	Number of years of experience in garlic cultivation
Other crop cultivation	Other crops grown in addition to garlic
Land under other crops	Agriculture land of farmers on which they grow any other crop
Source of financing	The main source of financing for garlic cultivation (own savings, bank loan, etc.)
Source of irrigation	The main source to irrigate the crops (Rain, Canal water , Tube wells etc.)
Seed source preference	Preference for purchasing G1 garlic seeds from a specific source (local supplier, online, etc.)
Farming experience	Years in farming or agriculture business

Table 1

After Identifying the profitability of each crop and comparing them, seed price cost of each crop is varied by increasing and decreasing them by a factor to identify sensitivity of profitability to the seed prices. Impact of each net profit margin, gross profit margin and return on investment was observed. After the sensitivity analysis, to analyse what other significant factors are impacting the profitability an economic model was developed. The model focused on factors that can play important role in defining the returns on G1 Garlic Investments.

$$Y = \beta_O + \sum_{i=1}^{n} \beta_i X_i + \mu$$

Equation 3

Here i = 1, 2, …., n are inputs, yi is output of the Farm ; Xi is the level of i-th input on the farm, β_i is parameters including intercept to be estimated, μ_i is error term.Now Y is the profitability of farm, and we can define it as a function of X variables. We consider following variables that can influence the profitability of Garlic Farms. We ca define profitability as a function of various variables the production function will be as follows.

Profitability (Y) = f Σ (seed price per acre, Land preparation, pesticide cost, storage cost, Irrigation cost, fertilizer Cost, Farming Experience in years, Labour cost, Garlic Farming Experience in years, Education, Associated land)

Phase 2:

During the second Phase of the study, we would identify the preference dynamics of G1 garlic to household, Consumer Choice experiment will be conducted. One of the most important characteristics of CCEs is their ability to imitate real-world decision-making. Researchers can construct a realistic decision-making environment that closely matches actual consumer behaviour by providing participants with a succession of hypothetical scenarios and variable features. This enables estimating customer demand and preferences for new products or services and assessing the potential impact of policy initiatives easier. According to (Flynn & Marley, n.d.), CCEs provide a more realistic picture of consumer decision-making than other methods such as surveys or focus groups. Another essential characteristic of CCEs is their capacity to capture the significance of many product features. Researchers can assess which features are most essential to customers and how much they are prepared to pay for those qualities by presenting participants with different options and traits. This is especially important in product development and marketing, as corporations may use CCEs to build items that better fit the wants and preferences of their customers. According to (Hensher et al., 2015), CCEs give a method for measuring the value of various product features and how they contribute to overall consumer utility. CCEs are a valuable tool for analysing customer preferences and decision-making in general. Researchers can evaluate

consumer demand for new items by presenting participants with hypothetical scenarios and altering features.

Variable	Description
Age	Age of the respondent
Gender	Gender of the respondent
Education	Highest level of education attained by the respondent
Income	Annual income of the respondent
Occupation	Current occupation of the respondent
Frequency of Garlic consumption	How often the respondent consumes garlic (daily, weekly, monthly, rarely, etc.)
Garlic purchasing frequency	How often the respondent purchases garlic (daily, weekly, monthly, rarely, etc.)
Awareness of garlic types	Whether the respondent is aware of different garlic varieties
Source of garlic purchase	Where the respondent usually purchases garlic (local market, supermarket, online, etc.)

Table 2

For this purpose, a well-structured survey questionnaire is developed and presented to various vegetable buyers of Mianwali city. Questionnaire comprised of questions including socioeconomic information of the respondent, size of the market, respondents knowledge of various uses of garlic, knowledge of various varieties of Garlic, frequency of buying garlic & about the choice experiment where on the basis of various attributes and their levels consumer would be asked to choose one or a combination of their preferred variety between the G1 Garlic, Desi Garlic and Chinese garlic. The attributes and their levels are given below in the table. Questions in this part would determine preferred attributes of a garlic by the customers.

Attributes	Description

Appearance	Colour, Size, Weight, No. of Cloves
Kitchen Handling	Ease to grind/peel/chop, Storage, Cooking time
Health Benefits	Role in cholesterol control, Presence of Allicin etc
Availability	Price, Market, Ease to access
Flavour	Taste, Pungency, Bitterness, Texture

Table 3

Chapter 4 Results

Cost of production and Sensitivity Analysis

The expenditure associated with seeds is a fundamental component of agricultural production. In this study, we examine the seed costs associated with G1 Garlic, a variety known for its high yield potential, in comparison to non-Hybrid seeds. According to **Error! R eference source not found.**The seed cost for G1 Garlic is found to be remarkably high, amounting to Rs 404,759 per Kanal. Conversely, non-Hybrid seeds are observed to be priced significantly lower, at Rs12,000 per Kanal. Seed bed preparation is a pivotal stage in the establishment of crops, as it plays a crucial role in ensuring successful germination and subsequent growth. In this study, the cost of cultivating the Hybrid G1 crop is reported to be Rs6,313 per Kanal

Cost	Hybrid G1 Sold Fresh	Hybrid G1 Sold Dry	Non-Hybrid
Per Kanal Seed Cost	Rs 404,759	Rs 404,759	Rs 12,000
Seed Bed Preperation cost per Kanal	Rs 6,194	Rs 6,194	Rs 7,000
Fertilizer cost per Kanal	Rs 16,357	Rs 16,357	Rs 5,500
Irrigation Cost Per Kanal	Rs 3,006	Rs 3,006	Rs 800
Pesticide cost per canal	Rs 10,910	Rs 10,910	Rs 3,500
Per Canal Weedicide cost	Rs 210	Rs 210	Rs 210
Labor Cost Per Kanal	Rs 9,383	Rs 9,383	Rs 3,500
Storage cost per kanal	Rs 51,491	Rs 51,491	Rs 50,000
Total Cost	**Rs 502,309**	**Rs 502,309**	**Rs 82,510**
Total yield per Kanal Kg	979	326	700
Revenue (80% Produce Sold)	Rs 1,565,663	Rs 2,087,551	Rs 224,000
Net Profit	**Rs 1,063,354**	**Rs 1,585,242**	**Rs 141,490**

Table 4 Cost of Production Analysis

In contrast, non-Hybrid cultivation necessitates a marginally greater financial commitment of Rs7,000 per Kanal. The application of fertilizer plays a crucial role in ensuring optimal nutrition for crop growth and development. The cost of fertilizer for Hybrid G1 is Rs17,381 per Kanal. Non-hybrid cultivation has emerged as a viable and cost-effective option in this context, demonstrating a reduced expenditure of Rs5,500 per Kanal.

The implementation of efficient irrigation practices is of paramount importance for the overall well-being of crops, and it necessitates the allocation of financial resources. The cultivation of Hybrid G1 crops necessitates an irrigation cost of Rs3,006 per Kanal, whereas non-Hybrid cultivation requires a significantly reduced investment of Rs800 per Kanal. The reason behind the high irrigation cost is that G1 Garlic requires a greater number of irrigations per cycle than the non-hybrid varieties.

The implementation of pest control measures is of utmost importance in safeguarding agricultural crops from the detrimental effects of pests. However, it is worth noting that such endeavors incur certain financial costs. The cost of Hybrid G1 for pest control is quantified at Rs12,338 per Kanal in comparison to Rs.3,500 for non-hybrid variety. This suggests that hybrid variety requires more pesticides and is prone to various diseases.

The management of weed populations is of paramount importance for the overall well-being and productivity of agricultural crops. The present study reveals a noteworthy observation regarding the cost of weedicides, which exhibits a consistent value of Rs210 per Kanal across various crop types. This finding implies that the financial outlay associated with weed management practices remains relatively uniform irrespective of the specific crop being cultivated. The expenditure associated with labor, a pivotal element in the process of cultivation, is a significant consideration. The Hybrid G1 model is associated with labor costs amounting to Rs9,883 per Kanal. Non-hybrid cultivation exhibits a marginal reduction in labor expenses, amounting to Rs3,500 per Kanal, suggesting a plausible advantage in terms of labor-related costs.

The storage of harvested crops is a critical process that plays a pivotal role in maintaining the quality of the crops and ensuring their suitability for future utilization. In this study, we compare the storage costs of Hybrid G1 and non-Hybrid varieties. Our findings reveal that both varieties demonstrate nearly indistinguishable storage costs, with Hybrid G1 costing approximately Rs51,491 per Kanal and the non-Hybrid variety costing approximately Rs50,000 per Kanal.

The productivity of a given crop, as quantified by its overall yield, plays a pivotal role in determining the financial viability of agricultural operations. The experimental results indicate that the G1 garlic variety exhibited a significantly high yield of 979 kg of fresh garlic per kanal. Upon the process of drying, the variety in question experiences a reduction in weight by two-thirds. Consequently, the yield of dried garlic per unit area, specifically per Kanal, diminishes to a value of 326 kg. In contrast, the non-hybrid variety exhibits a yield of approximately 700 kilograms of garlic per Kanal.

The calculation of revenue generation was conducted under the assumption that 80% of the agricultural yield is allocated for sale by the farmers, while the remaining 20% is retained for cultivation purposes in the subsequent year. The analysis of revenue reveals significant disparities that warrant attention. In this study, we examine the financial returns of the hybrid G1 variety when sold in fresh and dry conditions, as well as the non-hybrid variety. The hybrid G1 variety, when sold in fresh condition, demonstrates a significant financial return of Rs1,565,663 per Kanal. This indicates the potential profitability of cultivating and selling this variety in its fresh state. On the other hand, the hybrid G1 variety, when sold in dry condition, exhibits a higher monetary yield of Rs2,087,551 per Kanal. This suggests that the dry form of the hybrid G1 variety may offer even greater financial benefits compared to its fresh counterpart. In contrast, the non-hybrid variety generates a comparatively lower financial return of Rs224,000 per Kanal. This finding highlights the potential disparity in profitability between hybrid and non-hybrid crops.

The results of our study reveal that Hybrid G1 (Fresh) exhibits a net profit of Rs1,060,283 per Kanal. This indicates the financial gain achieved by cultivating this hybrid variety. Similarly, Hybrid G1 (Dry) demonstrates a higher net profit of Rs1,582,171 per Kanal, suggesting its potential for greater economic returns compared to Hybrid G1 (Fresh). On the other hand, the non-Hybrid variety yields a net profit of Rs141,490 per Kanal, indicating its comparatively lower profitability. These findings shed light on the economic viability of different crop varieties and provide valuable insights for farmers and agricultural practitioners. Further research and Based on the findings of the cost of production analysis, it has been determined that the expenses related to the cultivation of the G1 variety are relatively greater in comparison to non-hybrid varieties. Nevertheless, it has also been observed that the returns obtained from the G1 variety are correspondingly higher when compared to the non-hybrid varieties. The observed variety exhibits a notable increase in profitability when marketed in

its fresh seed form, and an even more substantial increase in profitability when marketed in its dried state.

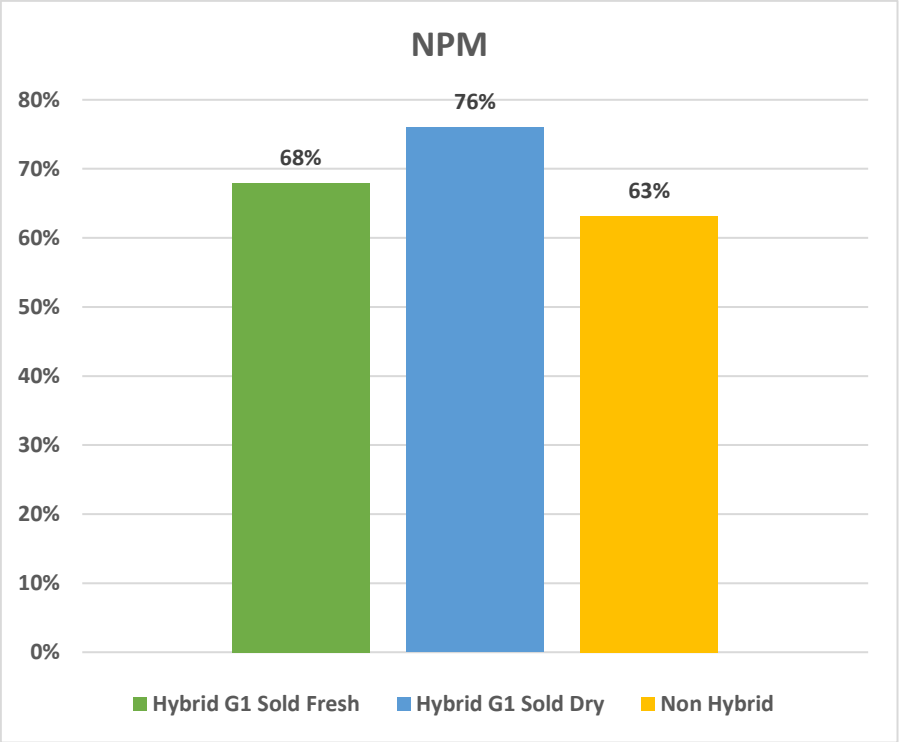

Figure 10 Net Profit Margin

Upon examination of the Figure 10, it is evident that the net profit margin for the Hybrid Variety surpasses that of the non-hybrid Variety. The observed values are further elevated when the assortment is marketed in a desiccated state. The non-hybrid variety exhibits a net profit margin (NPM) of approximately 63% upon sale. In contrast, the G1 variety demonstrates a higher NPM of 68% for its fresh form and an even more substantial NPM of 76% for its dry form.

Similarly, the Return on investments for Hybrid Variety is higher than non-hybrid VarietyFigure 11. It is even higher when variety is sold in dry form. When non hybrid variety is sold it gives around 171% return on money invested. G1 variety generates a return of 212% and 316% on money invested when sold fresh or dry, respectively.

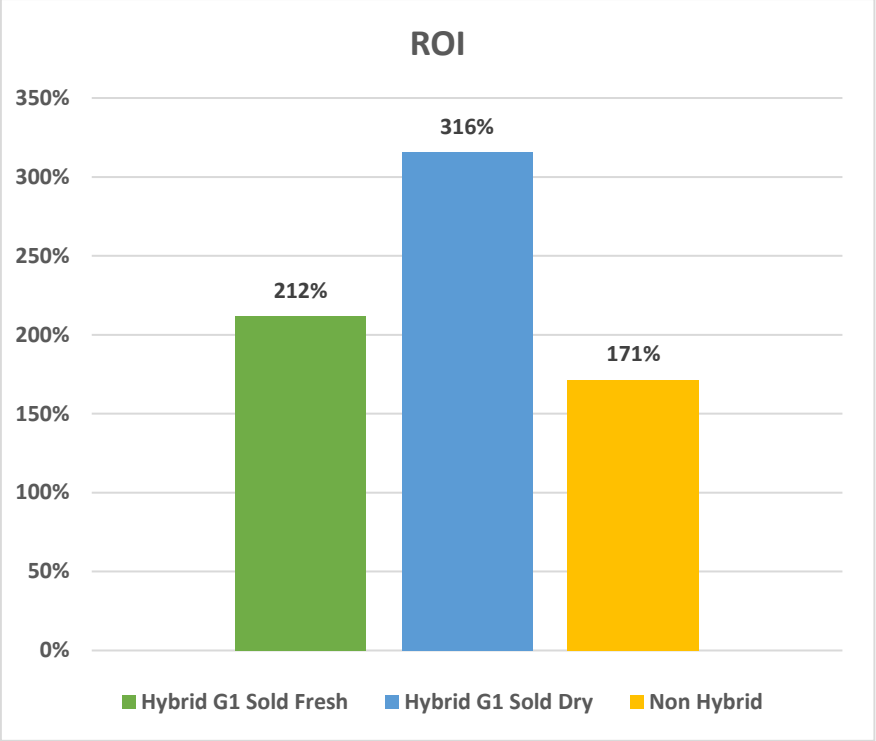

Figure 11 Return on Investment

Sensitivity Analysis

Upon examination of the content from Figure 12, it is evident that a 10% increase in seed cost yields a corresponding 3.8% decrease in net profit for G1 Garlic when sold in its fresh form. The findings of this investigation reveal a negative correlation, as evidenced by a 7.6% decrease in net profit following the 20% increase in seed cost. Further it was observed that a reduction in seed cost by 10% led to a subsequent increase in net profit by 3.8%. Furthermore, a subsequent reduction in seed cost by 20% resulted in a more substantial increase in net profit by 7.6%. These findings suggest a positive correlation between seed cost reduction and net profit increase.

In the case of Hybrid G1 Sold Dry, it has been observed that a 10% increase in seed cost leads to a corresponding decrease in net profit by2.6%. Our findings reveal a corresponding decrease of 5.1% in net profit as a result of a 20% cost escalation. In the case of Hybrid G1 Sold Dry, it has been observed that a reduction of 10% in seed cost leads to a corresponding increase of 2.6% in net profit. The findings of this study reveal a statistically significant increase of 5.1% in net profit following the 20% decrease in seed cost.

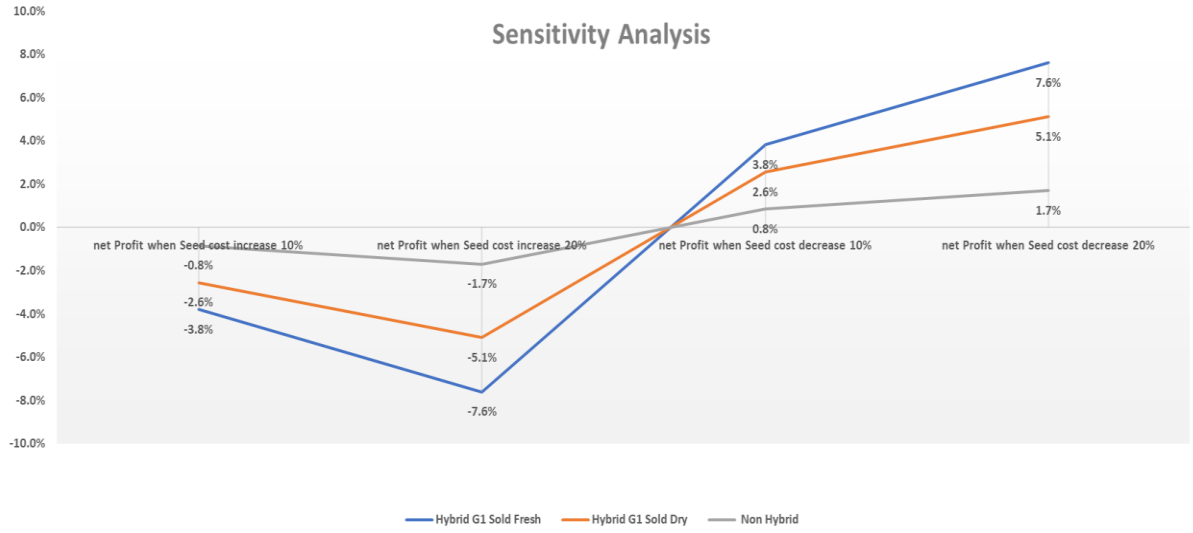

Figure 12 Sensistivity Analysis

In the case of Non-Hybrid Variety, it has been observed that a 10% increase in seed cost leads to a corresponding decrease in net profit by 0.8%. In the context of agricultural economics, it has been observed that a proportional increase in seed cost by 20% leads to a corresponding reduction in net profit of 1.7%. In the case of non-Hybrid, a reduction in seed cost by 10% and 20% leads to a corresponding increase in net profit by 0.8% and 1.7% respectively. This finding highlights the negative impact of rising seed costs on the overall profitability of agricultural operations.

Similarly, the results shown in figure state that whenever the seed prices were increased by 10% and 20%. The NPM fell to 74% and 72% respectively from original value of 76% for G1 Garlic sold Dry. However, similar deduction in seed cost resulted in opposite results. The results show NPM of 78% and 80% for the 10% cost deduction and 20% cost deduction for G1 sold Dry.

For G1 Garlic sold fresh, figure state that whenever the seed prices were increased by 10% and 20%. The NPM fell to 65% and 63% respectively from original value of 68%.However, similar deduction in seed cost resulted in opposite results. The results show boost of NPM to 71% and 83% for the 10% cost deduction and 20% cost deduction.

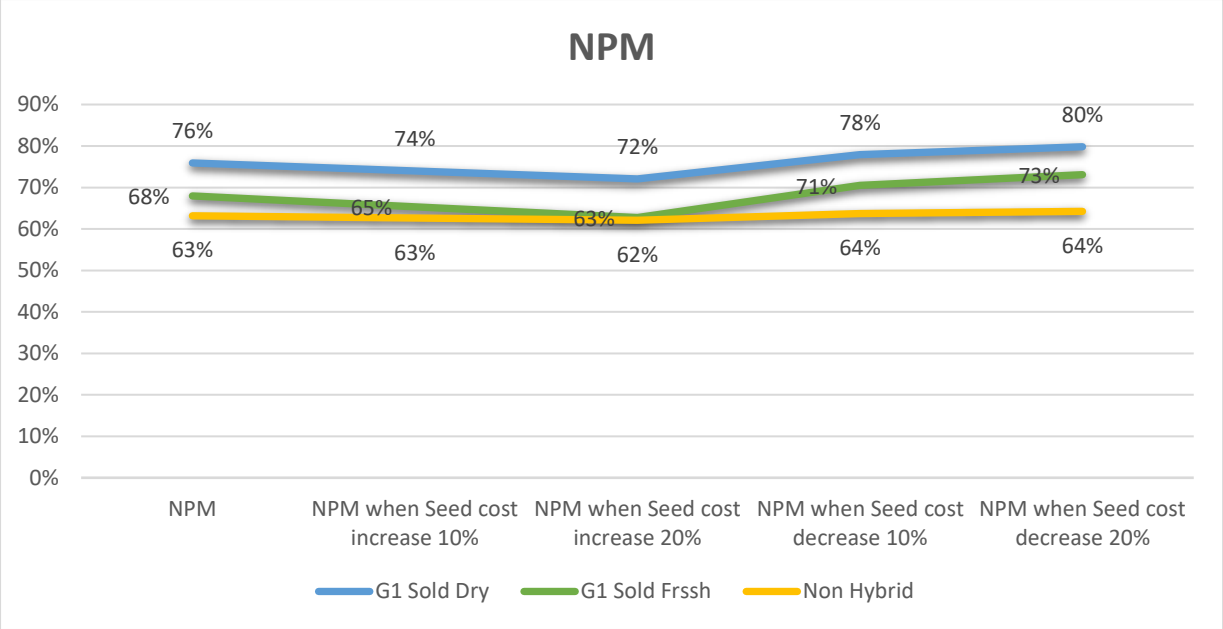

Figure 13 Changes in NPM

For non-hybrid variety, figure state that when the seed prices were increased by 10% there was no significant impact seen however an increase 20% resulted in a value drop to 62%. The cost deduction of 10% resulted in value boost to 64 % while 20% also resulted in boost to 64%.

Similarly, the results shown in the figure state that whenever the seed prices were increased by 10% and 20%. The ROI fell to 285% and 258% respectively from original value of 316% for G1 Garlic sold Dry. However, a similar deduction in seed cost resulted in opposite results. The results show ROI of 352% and 395% for the 10% cost deduction and 20% cost deduction for G1 sold Dry.

For G1 Garlic sold fresh, the figure state that whenever the seed prices were increased by 10% and 20%. The NPM fell to 188% and 168% respectively from original value of 212%. However, a similar deduction in seed cost resulted in opposite results. The results show boost of NPM to 239% and 272% for the 10% cost deduction and 20% cost deduction.

For non-hybrid variety, the figure shows a straighter line instead of a curve hinting in a change not very significant. According to the figure when the seed prices were increased by 10% and 20% there was addition of 3% and 4% in original value of 171% respectively. The cost deduction of 10% resulted in a value boost to 175% % while 20% resulted in boost to 180% ROI.

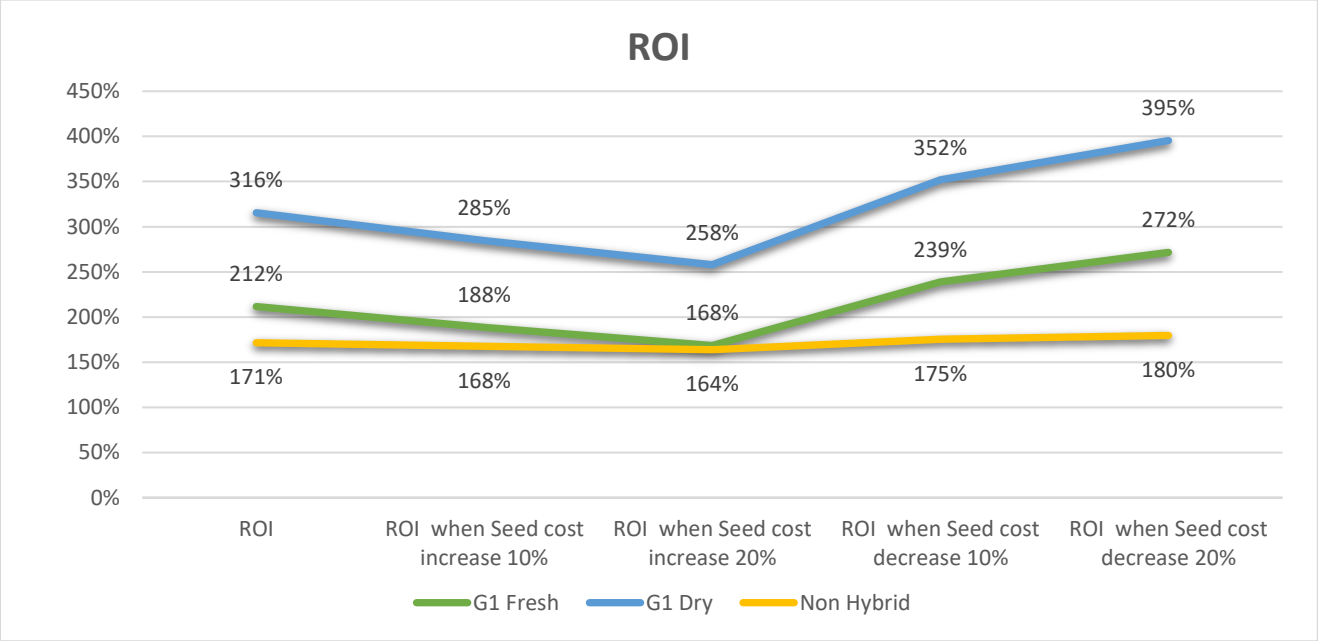

Figure 14 Changes in ROI

Regression Analysis:

Based on the Table 5, the model demonstrates that the R-value is 0.911, suggesting a robust positive correlation between the combination of predictor variables and the dependent variable associated with garlic farming. This observation implies that the combination of these predictors' accounts for a substantial proportion of the variance in the dependent variable. The coefficient of determination, commonly referred to as R-squared, is calculated to be 0.831. This metric quantifies the fraction of the variability observed in the dependent variable that can be explained by the predictor variables incorporated within the model. In the present study, it is observed that the predictors included in the analysis account for approximately 83.1% of the variance in the dependent variable. The adjusted R-squared value, denoted as R^2_adj, is a statistical measure that assesses the goodness of fit of a regression model by accounting for the number of predictors included in the model. In the present study, the calculated R^2_adj value is determined to be 0776. The adjusted R-squared metric incorporates the number of predictors included in the model, thereby yielding a more cautious evaluation of the model's ability to explain the observed variation in the response variable. The observed metric, while marginally below the R-squared value, nevertheless suggests a robust alignment between the model and the dataset.

Model	R	R square	Adjusted R Square	Std. Error of Estimate
1	.911[a]	.831	.776	43750.8732

Dependent Variable	Predictors
Gross Profit	Constant , Seed Cost, Seed Bed Preparation cost, Fertilizer cost, Irrigation cost, Pesticide cost, labor cost, education, years of farming , Years in garlic farming, Associated Land

Table 5 Model Summary

In summary, this model summary presents supplementary statistical measures for evaluating the adequacy of fit and efficacy of the multiple regression model. The obtained R-squared value of 0.831 suggests a substantial proportion of the variability observed in the dependent variable can be accounted for by the predictor variables. The obtained adjusted R-squared value of 0.776 indicates that the model retains its explanatory capacity even after accounting for the inclusion of multiple predictors. The quantification of the typical deviation between observed and predicted values, known as the standard error of the estimate, is a valuable metric for assessing the accuracy of a model. In this particular case, the standard error of the estimate is determined to be 437,450.87. The statistical data presented in this study provides substantial evidence to support the hypothesis that the proposed model effectively elucidates the correlation between the designated predictors and the dependent variable within the domain of garlic cultivation.

The constant term in the model is estimated to be 1.198, with a corresponding t-value of 1.198 and a p-value of 0.240. The value denotes the estimated mean value of the dependent variable under the condition that all other predictors possess a value of zero.

Model		Standardized Coefficients Beta	t	Sig.
1	(Constant)		1.198	.240
	Per Kanal Seed Cost	-.852	-10.538	<.001
	Seed Bed Preperation cost per Kanal	-.201	-2.372	.024
	Fertilizer cost per Kanal	-.033	-.409	.685
	Irrigation Cost Per Kanal	-.113	-1.345	.188
	Pesticide cost per canal	.315	3.745	<.001
	Labor Cost Per Kanal	-.325	-3.543	.001
	Education	.107	1.291	.206
	Associated Land (Kanal)	-.279	-2.515	.017
	Years Of Farming Experience	.302	3.089	.004
	Years in Garlic farming	.373	3.122	.004

Table 6 Coefficeints of Variables

The present study reports the standardized coefficient (Beta) for Per Kanal Seed Cost as -0.852 Table 6The observed relationship suggests that there is a negative correlation between the independent variable, Per Kanal Seed Cost, and the dependent variable. Specifically, for every one standard deviation increase in Per Kanal Seed Cost, there is a corresponding decrease of 0.852 standard deviations in the dependent variable. The predictor variable, Per Kanal Seed Cost, exhibits a t-value of -10.538, indicating a substantial deviation from the null hypothesis. Furthermore, the associated p-value is found to be less than 0.001, which provides strong evidence to support the claim that Per Kanal Seed Cost is a statistically significant predictor in the given context.

The standardized coefficient for the variable "Seed Bed Preparation Cost Per Kanal" is -0.201. The observed relationship between the independent variable, cost, and the dependent variable is characterized by a decrease of 0.201 standard deviations in the latter for every one-unit increase in the former, specifically for each standard deviation increment. The obtained t-value for the predictor variable is -2.372, suggesting a statistically significant relationship. Additionally, the corresponding p-value is 0.024, further supporting the significance of this predictor.

The standardized coefficient for the variable "Fertilizer Cost Per Kanal" is estimated to be -0.033. This value indicates a weak negative relationship between the variable and the dependent variable. The obtained t-value of -0.409 and the corresponding p-value of 0.685 suggest that the Fertilizer Cost Per Kanal does not exhibit statistical significance in its ability to predict the dependent variable.

The standardized coefficient for the variable "Irrigation Cost Per Kanal" is -0.113, suggesting a weak negative correlation between this variable and the outcome of interest. The obtained t-value for the predictor variable is -1.345, indicating a negative relationship. The corresponding p-value is 0.188, which exceeds the conventional threshold of statistical significance ($\alpha = 0.05$). Therefore, based on these results, it can be concluded that this predictor is not statistically significant in predicting the outcome variable.

The standardized coefficient (β) for the variable "Pesticide Cost Per Canal" is 0.315, indicating a positive association with the dependent variable. The obtained t-value for the predictor variable "Pesticide Cost Per Canal" is 3.745, with a corresponding p-value of less than 0.001. These results suggest that the predictor variable is statistically significant in predicting the outcome variable.

The standardized coefficient for Labor Cost Per Kanal is -0.325, suggesting a negative association. The obtained t-value of -3.543 indicates a statistically significant relationship between the predictor variable, Labor Cost Per Kanal, and the outcome variable. This is further supported by the p-value of 0.001, which falls below the conventional significance level of 0.05. Therefore, we can conclude that Labor Cost Per Kanal is a statistically significant predictor in the given context.

The standardized coefficient (β) for the variable Education is 0.107, indicating a positive association between Education and the outcome variable.The obtained t-value of 1.291 and the corresponding p-value of 0.206 suggest that the variable "Education" does not exhibit statistical significance in the context of the analyzed data.

The standardized coefficient for the variable "Associated Land (Kanal)" is -0.279, which suggests a negative association between this variable and the outcome of interest.The obtained t-value for the variable "Associated Land (Kanal)" is -2.515, with a corresponding p-value of 0.017. These results indicate that there is a statistically significant relationship between the variable "Associated Land (Kanal)" and the outcome of interest.

The standardized coefficient (β) for the predictor variable "Years Of Farming Experience" is estimated to be 0.302, suggesting a positive relationship between this variable and the outcome variable. The obtained t-value for the variable "Years Of Farming Experience" is 3.089, which surpasses the critical value at the desired significance level. Consequently, we reject the null hypothesis and conclude that there is a statistically significant relationship

between Years of Farming Experience and the outcome variable. The associated p-value is calculated to be 0.004, further supporting the statistical significance of the relationship.

The standardized coefficient (β) for the variable "Years in Garlic Farming" is 0.373, indicating a positive relationship between this variable and the outcome variable under investigation. The obtained t-value of 3.122 suggests a statistically significant relationship between Years in Garlic Farming and the variable under investigation. Additionally, the corresponding p-value of 0.004 further supports the notion of statistical significance.

The results of the analysis identified the factors that are statistically significant predictors of the dependent variable. The findings possess significant value in facilitating informed decision-making within the realm of garlic farming practices, resource allocation, and management.

Phase 2

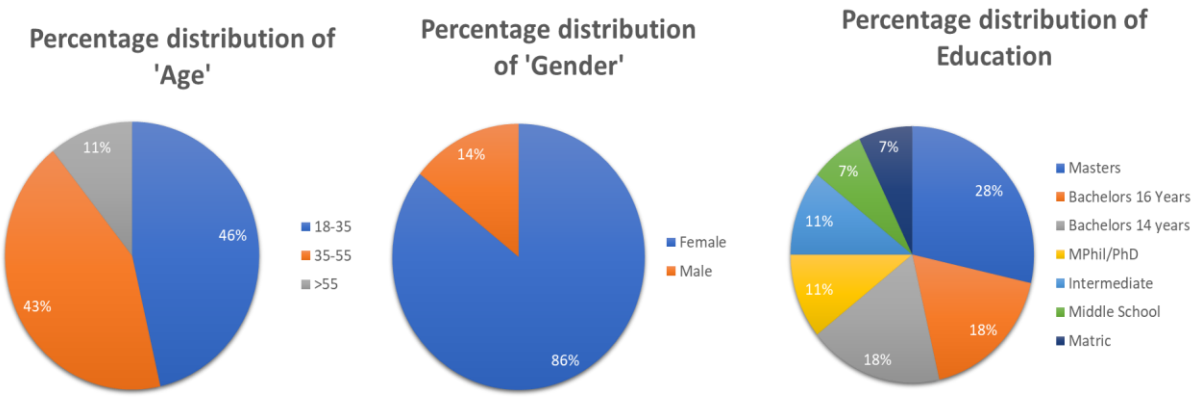

Figure 15

During the second phase of study 30 responses were collected from consumers based on the Choice experiment. 46% of the respondents belonged to the 18-35 age range. Respondents in age group of 35-55 were 43% while remaining 11% belonged to above 55 age group. Out of the 30 respondents 86% of the respondents were female(Figure 15). Looking at the education demographic 28% respondents had a Masters degree while 18% had a bachelors degree with 14 year education. Similar were the stats for the Bachelors with 16 years of education. Looking at Ph.D./ MPhil and Intermediate level education stats, there were 11% respondents for each category. While Middle School education and education till Matriculation comprised of 7% respondents for each category.

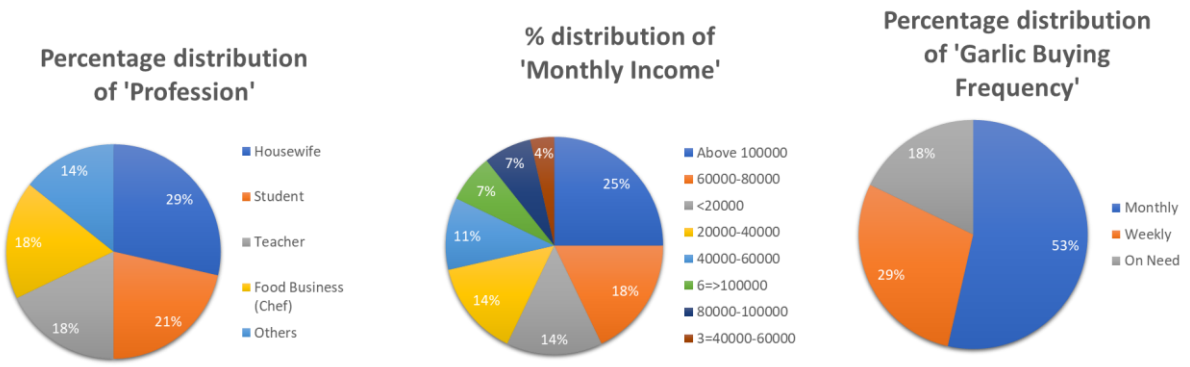

Figure 16

If we look at the professions of the respondents 29% respondents were housewives while 21% were students. While 18% of respondents belonged to Teaching and Food Business each. 25% of respondents had their income above Rs. 100000. While 18% respondents belonged to income group of 60000-80000 per month. Income group of <20000 and 20000-40000 had 14% respondents each. 53% of the respondents identified that the buy their ongarlic monthly basis while 29% buy it on weekly basis. Remaining 18% of the respondents stated that they buy garlic on need basis(Figure 16).

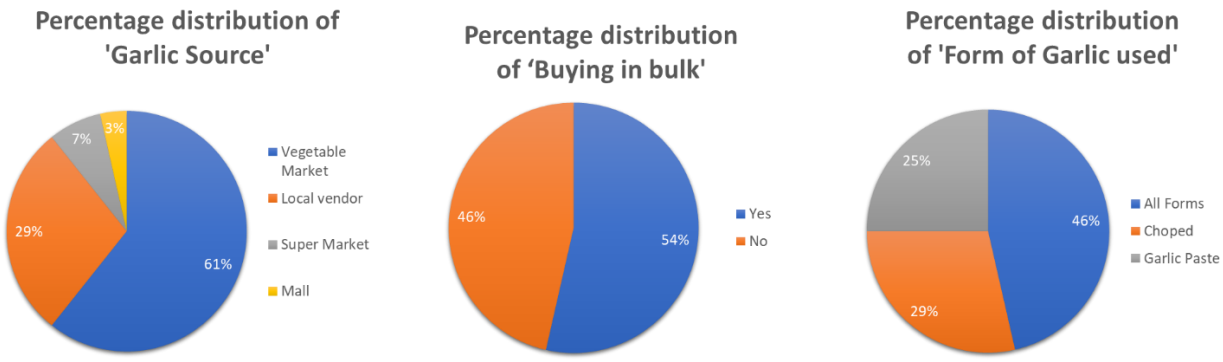

Figure 17

The Figure 19show that majority of respondents 61% buy garlic from vegetable market. While Local market being second largest source with 29% respondents going for this option. 54% respondents stated that they buy Garlic in Bulk. When asked about the form they use Garlic in? 46% respondents identified that they use garlic in all forms (Chopped, Paste, Powder). 29% respondents stated that they use garlic in Chopped form only. While 25% use garlic in paste form.

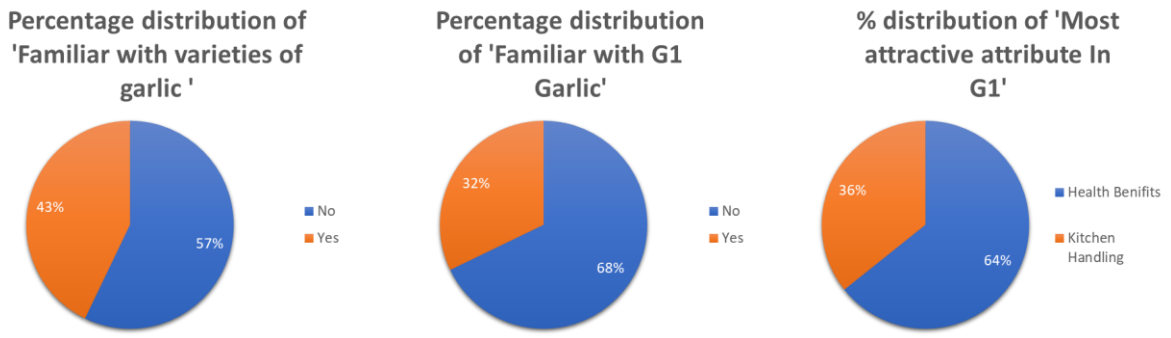

Figure 18

When inquired about familiarity with Garlic varieties 57% respondents were familiar with various varieties of Garlic. Out of these 57% respondents 68% were familiar with G1 Garlic Variety. After detailed visual introduction to various Garlic varieties respondents were asked about most attractive attribute in G1 Garlic. 64% respondents stated health benefits and 36% identified kitchen handling as the most attractive attribute of G1 Garlic.

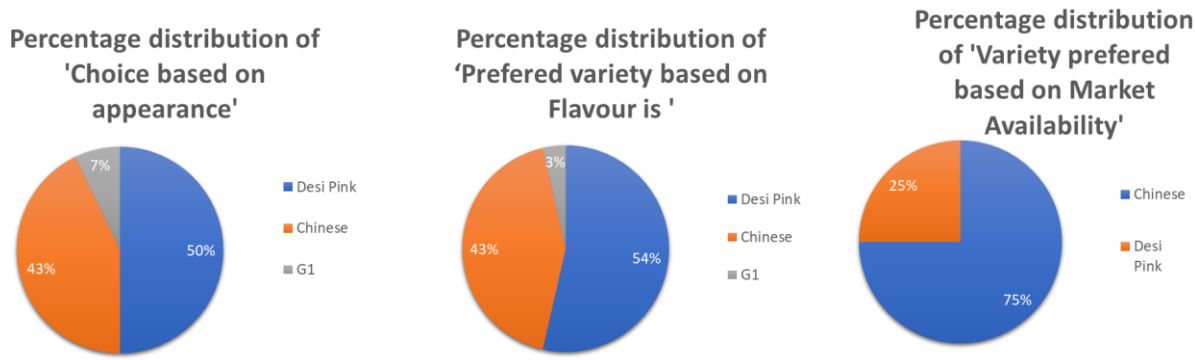

Figure 19

Consumers were asked about their variety preference based on various attributes. Consumers responded that based on Appearance alone the most desirable variety for the is Desi Pink Garlic 50% of the respondents opted for this variety. Chinese garlic was opted by 43% while only 7% choose the Hybrid G1 variety. Based on Flavour profile also the most desirable variety remained the desi Pink Garlic with 54% while 43% opted for Chinese one only 3% felt that G1 has a more desirable flavour profile. Based on market availability, the majority (75%) respondents went for the Chinese variety. While remaining opted for the Desi Pink

Garlic.

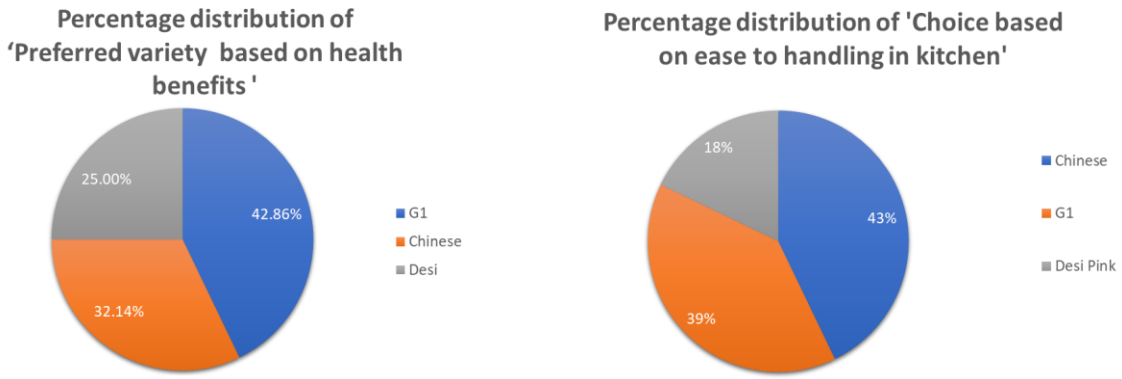

Figure 20

Based on health benefits consumers preferred the Hybrid G1 Variety with 42.86% respoondents. While Based on ease to handle in kitchen G1 was also the first choice with 43% respondents going for the hybrid variety.

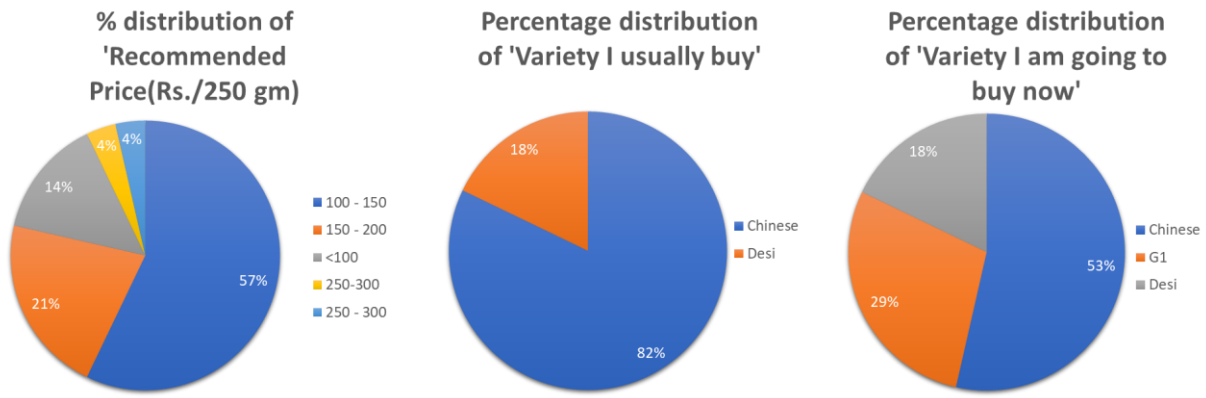

Figure 21

When asked about what the recommended price for 250 gm of G1 Variety should be, majority 57% recommended the price range pf Rs. 100-150. While 21% recommended the price range of Rs. 150-200. According to the study 82% respondents buy Chinese variety while only 18% buy desi variety. After the survey 29% respondents agreed on buying G1 garlic for their household. Considering these results there is a bright chance for this variety to attract several households if marketed well.

Chapter 5 Conclusion

Garlic Variety G1 (G1) represents a significant opportunity for the garlic industry, but it must overcome a number of obstacles to realize its full disruptive potential. Based on the comprehensive analysis conducted, it is evident that the cost of seeds plays a crucial role in the overall cultivation process. Therefore, it is imperative to give meticulous attention to devising strategies that can effectively alleviate this financial burden imposed on farmers. Furthermore, the process of transitioning from exclusively selling G1 as a seed to promoting it as a marketable product may have significant implications on pricing dynamics and financial returns. As such, it becomes imperative to adopt a well-calibrated and balanced approach in order to effectively navigate these potential challenges and maximize the overall success of the endeavor. The deficient presence of a well-established market infrastructure and the dearth of comprehensive guidance and support mechanisms have significantly impeded the reputation and market penetration of G1. The implementation of a well-organized and regulated market system, coupled with the provision of comprehensive and detailed guidance to farmers, plays a pivotal role in significantly improving the marketability of G1. In order to effectively address the potential negative consequences arising from uncontrollable factors, it is imperative to implement proactive measures alongside ongoing efforts. One such factor that warrants attention is the occurrence of excessive rainfall, which can have detrimental effects on the final stages of development, particularly by facilitating the spread of diseases that cause bulbs to rot in final stages. Therefore, it is crucial to adopt strategies aimed at mitigating the impact of such uncontrollable factors, thereby safeguarding the overall progress and success of the endeavor. One of the most noteworthy attributes of G1 is its remarkable health-promoting properties, which possess the capacity to captivate a considerable population of consumers. Exploiting and leveraging the inherent nutritional and

medicinal attributes of a product is of utmost importance when attempting to establish a distinct and specialized presence within the health-conscious consumer market.

In conclusion, the sustainability and success of G1 in the garlic industry are intricately linked to the implementation of a comprehensive and integrated strategy that takes into account the multifaceted elements elucidated in this research investigation. In order to optimize the efficiency and effectiveness of agricultural practices, it is imperative to adopt a comprehensive approach that integrates various strategies. These strategies, which encompass the reduction of seed cost, the establishment of a resilient market, the provision of essential guidance, and the management of environmental risks, should be implemented in a synergistic manner. Firstly, the reduction of seed cost is a critical aspect of agricultural sustainability. By employing advanced breeding techniques and genetic engineering, it is possible to develop high-yielding crop varieties that require fewer resources and inputs. Additionally, the utilization of precision agriculture technologies can enhance seed placement and optimize resource allocation, thereby minimizing wastage and lowering overall seed expenses. Secondly, the establishment of a robust market is essential for ensuring the viability and profitability of agricultural endeavors. This can be achieved through the implementation of effective marketing strategies, such as market diversification and value chain integration. By expanding market by capitalizing on its inherent health-promoting properties, G1 has the potential to establish a strong foothold in a market characterized by discerning consumers who prioritize their well-being and actively seek out products that offer superior quality and optimal nutritional content. In order to successfully attain these objectives, it is imperative that future scientific investigations and collaborative endeavors be undertaken to expedite the establishment of G1 as a preeminent cultivar of Allium sativum, commonly known as garlic, within both the agricultural and consumer domains not just on household domain but on industrial domain as well.

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