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COMPARATIVE STUDY ON TOMATO VARIETIES SELECTION IN THE PROTECTED CONDITIONS OF JORDAN VALLEY FOR YIELD AND PEST RESISTANCE

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KEYWORDS

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Protected cultivation
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Yield performance
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ABSTRACT

This study is significant for its applicability in screening tomato varieties under the protected cultures of the Jordan Valley with pest management practices. The experiment aimed to compare the performance of three tomato varieties (Dafnis, SV4129, and Newton) grown in the protected cultures of the Jordan Valley in terms of yield, and resistance to fungal diseases and viral infections. The varieties selected are among the most preferred varieties in the Jordanian market and are widely adopted by local growers. The research evaluated yield and key quality traits, including plant vigor, internode length, flowering, and fruit set, as well as important plant and fruit characteristics for each variety. The varieties were cultivated under greenhouse conditions in the Jordan Valley over one growing season, from 1 October 2023 to the end of March, with a growth period of approximately 150 days. The highest yield was obtained from the Newton cultivar. The results indicated that Dafnis and SV4129 exhibited strong resistance to *Pythium*, *Fusarium*, and the viral diseases Tomato Yellow Leaf Curl Virus (TYLCV) and Tobacco Mosaic Virus (TMV). Based on these findings, Newton is recommended for cultivation under protected conditions in the Jordan Valley, where effective virus management is in practice. However, in production systems with inadequate virus control, the adoption of the Newton cultivar is not advised due to its higher susceptibility to viral infections.

INTRODUCTION

Tomato (*Solanum lycopersicum*), a herbaceous plant of the Solanaceae family, typically grows 1–3 m tall, with glandular stems, leaves measuring 10–25 cm, and yellow flowers approximately 2 cm in diameter (Acquaah, 2009; Munteanu, 2003). Native to South America, early tomato plants produced small green fruits in the mountainous regions of Peru, were domesticated in Mexico, and were later introduced to Europe, where they were initially considered poisonous (Acquaah, 2009; Bird, 2008). Optimal growth requires at least eight hours of sunlight per day, fertile, deep, well-drained soils, and a pH of 5.5–6.5, with the addition of compost or organic matter enhancing plant vigor (Georgescu et al., 2018). Tomato diseases often originate in soil and can also affect related crops such as peppers, eggplants, and potatoes (Docea et al., 2012). Globally, approximately 7500 tomato varieties exist, with hybrids preferred for early and uniform maturity, disease resistance, and superior fruit quality (Acquaah, 2009). While some regions allow direct sowing, most growers start seeds indoors and transplant seedlings 5–6 weeks after the last frost (Rai & Yadav, 2005). Temperature strongly influences growth, with optimal water uptake, development, and yield occurring between 18 and 28°C (Porter & Gawith, 1999). Environmental factors - including temperature, humidity, and light, as well as the genetic makeup - also affect fruit composition, such as organic acids, sugars, alcohol-insoluble solids, carotenoids, and lipids (Davies et al., 1981). Many physiological, pathological, and entomological challenges can be mitigated using genetic resources conserved in germplasm banks (Reed, 2004). Today, tomatoes are widely consumed as both fresh and processed products, including sauces, soups, and condiments, highlighting their global dietary and economic significance (Kirstie, 2005). Tomatoes are

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among the most important vegetables and greenhouse crops worldwide. In Southeastern Europe, approximately 3.63% of protected cultivation areas are devoted to tomato production, yielding roughly 13.7 million tons annually (Canton, 2021). Tomatoes are processed into numerous products, such as juice, paste, sauces, and powders, underscoring their industrial value (Porretta, 2019). Fresh tomatoes contain 80–95% water, and their nutritional composition varies with variety and agronomic practices (Erba et al., 2013). Globally, annual tomato production reaches approximately 50 million tons, with major producers including the United States, Russia, Italy, China, Turkey, Egypt, Spain, Greece, Brazil, and Romania (Chand & Kumar, 2016; Munteanu, 2003). Tomatoes are marketed for both fresh consumption and processing, with greenhouse cultivation playing a particularly important role in year-round production (Jones Jr, 2007). Tomato breeding has evolved to address yield, disease resistance, and post-harvest quality. Efforts intensified in the 1970s to improve yield, followed by breeding for disease resistance and extended shelf life in the 1980s, leading to the development of improved varieties, including dwarf varieties such as ‘Flavor Save’ (Yuan et al., 2025). The assessment of chemical and nutritional composition remains a key breeding objective to enhance fruit quality and meet market requirements. Climate change, particularly rising global temperatures, poses significant challenges to tomato production while simultaneously driving the development of heat-tolerant varieties. In Mediterranean regions, heat stress is a major abiotic constraint, reducing yield, impairing fruit set and flower fertilization, and decreasing the chemical and nutritional quality of fruits, ultimately affecting marketability (Bacelar et al., 2024). In addition to abiotic stress, viral diseases represent a major threat to tomato production in both open-field and greenhouse systems. Tomato yellow leaf curl virus (TYLCV) is among the most destructive viruses affecting yield and fruit quality, second only to tobacco mosaic virus and tomato spotted wilt virus. Greenhouse cultivation, with elevated humidity levels, further promotes viral infection and transmission, emphasizing the importance of integrating breeding for resistance with effective management strategies (Petrov et al., 2024).

The major purpose of this research is to compare the performance of three tomato varieties (Dafnis, SV4129, and Newton) grown in the protected cultures of the Jordan Valley. Assessment of their yields, yield components, and resistance to fungal diseases and viral infections.

MATERIALS AND METHODS

A research study was conducted to identify the most suitable variety for cultivating tomatoes in Jordan Valley protected cultures. After evaluating various regions, the Jordan Valley was selected as the best site for the experiment. This decision was based on several consistent climatic factors crucial for tomato growth: relatively stable temperatures between day and night, consistent humidity levels, and moderate, predictable wind conditions. These stable environmental variables ensure a more reliable and controlled setting for agricultural research compared to other locations in the country.

Target experimental area

The experiment was conducted in the Jordan Valley across a split total area of half a hectare (0.5 ha). The selected tomato varieties represented the most prevalent and commercially viable varieties within the Jordanian market. To compare different varieties, the experimental site of 0.5 hectares occupied three greenhouses covering a total area of 0.14 ha (1404 m²). Each greenhouse was planted with a distinct variety: the commercial hybrids of SV4129, Dafnis, and the variety Newton. As the control group, Newton was the primary focus of this phenotypic performance comparison.

Brief description of the three greenhouses used in the experiment

Greenhouses were selected for the experiment to provide a protected environment that ensures suitable and consistent atmospheric conditions (uniform temperature and humidity). This controlled setting was vital for obtaining uniform plant growth under the same environmental and controlled factors, thereby guaranteeing practical results. A primary objective of this selection was to maintain the genetic integrity of the crops by preventing cross-pollination between the flowers of the different varieties.

The structural specifications for each of the three greenhouses were as follows:

1. Length: 52 meters.
2. Width (at ground level): 9 meters.
3. Total Area (per unit): 468 m².
4. Height: 300 cm (center apex); and 200 cm (sides).
5. Each green house was planted with 6 rows of each variety.

A brief presentation of the three tomato varieties that were used in experimentation

The study evaluated three tomato varieties (Table 1)—Dafnis, SV4129, and Newton—selected for their commercial prevalence and alignment with market preferences. Each variety exhibits distinct levels of sensitivity to pathogens and environmental stressors. The experimental seeds were sourced from industry leaders Syngenta and Seminis companies to ensure high yield and quality.

Table 1. Tomato varieties used in the experiment and their agronomic characteristics

Variety	Classification and growth habit	Key characteristics
Newton	Indeterminate Hybrid	Versatile for both open-field and greenhouse cultivation. Exhibits strong disease resistance and produces dark red fruit.
Dafnis	Indeterminate Hybrid	Considered a vigorous hybrid with dark green foliage. The fruit is round, medium-sized, and weighs between 200–250 grams.
SV4129	Indeterminate Hybrid	Characterized by early maturity and a high yield potential with medium fruit quality. This variety produces large fruit.

Characteristics of tomato varieties

Table 2 outlines the documented disease sensitivity profiles for each variety, establishing a baseline for the comparative analysis prior to the study.

Table 2. Documented disease sensitivity of the tomato varieties prior to experimentation

Variety	Sensitivity
Newton	Susceptible to soil diseases and fungi like *Pythium* and *Fusarium*.
	2. High tolerance to TYLCV* virus.
	3. Moderately sensitive to the TMV* virus.
Dafnis	Susceptible to soil diseases and fungi like *Pythium* and *Fusarium*.
	High tolerance to TYLCV* virus
	Tolerance to the TMV* virus.
SV4129	Tolerance to soil diseases and fungi like *Pythium* and *Fusarium*.
	High tolerance to TYLCV* virus.
	Susceptible to the TMV* virus

*TYLCV: Tomato yellow curl virus, TMV: tomato mosaic virus.

Greenhouses and irrigation system management

The field exposed to several rounds of manual plowing using a traditional hand plow, after which the soil was compacted into furrows to establish distinct planting lines/rows. The irrigation network was designed with a main line feeding 6 branched lateral lines, drawing water from an adjacent water pond. Following the initial tillage and the laying of the secondary irrigation pipes, the entire soil surface and irrigation system were covered with a black plastic mulch sheet. The irrigation system was then activated to thoroughly moisten the soil and increase its temperature. Once optimal moisture and warmth were achieved, planting holes were carefully bored into the plastic sheet at precise intervals. Based on a row spacing of 1.0 m and an intra-row spacing of 0.40 m, a greenhouse with a total area of 468 m^2 accommodates exactly 500 plants. And a 5 serving aisles for crop serving between the 6 plant lines, with 0.8 m in width. The experimental design is completely randomized design (CRD) with one variable.

Doses of fertilizers used in the experiment

Tomato plants generally require fertilization throughout their entire growing life cycle. The standard regime involves three main applications: the first occurs during transplanting of seedlings, the second when fruit sets (fruit binding), and the third follows initial fruit formation (Cunha-Chiamolera et al., 2026). In this study, nutrients were applied continuously via the irrigation system (fertigation) every two to three weeks. The fertilization program included all essential nutrients required for healthy growth: macronutrients (needed in large quantities, such as nitrogen, phosphorus, and potassium); secondary essential nutrients (e.g., calcium and magnesium); and various micronutrients, including zinc and boron. Table 3 details the fertilization regime implemented for all greenhouses. Prior to planting, a basal application of organic fertilizer was incorporated into the soil during the tillage phase at a rate of 3000 kg per unit. Subsequently, during the vegetative and reproductive stages, supplementary nutrients were provided through a scheduled fertigation program. This included N-P-K chemical fertilizers applied at a rate of 2–3 kg per greenhouse, alongside a micronutrient blend (Fe, Zn, and B) concentrated at 200 g.

Table 3. Outline of fertilizer types, application rates, and timing for the greenhouse experiment

Date	Foliar spray	Soil application
November 03.2022	Minor elements (fruit growth combination) + organic mater	×
November 28.2022	Fe 13.2% + 20-20-20 (N-P-K)	N-P-K (12-61-0)
December 03.2022	×	N-P-K (0-52-34)
December 07.2022		N-P-K (20-20-20)
December 11.2022		N-P-K (17-10-27)
December 15.2022	Minor Elements (fruit growth combination) + amino acid	×
December 17.2022	×	N-P-K (0-52-34)
December 20.2022		N-P-K (21-0-0) + Fe 6%
December 24.2022	P_2O_5 52% W/W + K_2O 42% W/W	×
December 30.2022	×	N-P-K (12-12-36)
January 03.2023		Fe 6%
January 13.2023		Calcium and magnesium sulfate
January 19.2023		N-P-K (0-52-34)
January 23.2023		N-P-K (17-10-27) + magnesium sulfate (16% MgO + 32% SO_3
January 28.2023		N-P-K (21-0-0) + Fe 6%
February 05.2023		N-P-K 1(7-10-27)
February 12.2023		Calcium and magnesium (Ca+Mg)
February 13.2023		Calcium and magnesium (Ca+Mg)
February 23.2023		N-P-K (46-0-0) + Fe 6%
February 27.2023	Free amino acids 62% + minor nutrients	×
February 28.2023	×	N-P-K (17-10-27)
March 03.2023		N-P-K (21-0-0) + Fe 6%
March 07.2023	N-P-K (18-18-18)	N-P-K (12-12-12)
March 10.2023	×	N-P-K (0-52-34)
March 13.2023		N-P-K (12-12-36)

×: nothing applied

Method used for pruning and pesticides used

Indeterminate tomato cultivars require regular pruning to optimize both productivity and fruit quality. In this experiment, all vegetative growth above the leaves and nodes was carefully removed to direct the plant's energy toward fruit development. Additionally, once the fruits reached an appropriate size, leaves surrounding the fruit were selectively pruned to improve sunlight exposure, thereby enhancing fruit coloration and quality (Aglave 2018). During both the vegetative and reproductive stages, a comprehensive phytosanitary program was implemented, incorporating preventive and curative pesticide applications. Table 4 summarizes the chemical agents used throughout the growth life cycle, the specific pathogens targeted, and the corresponding control measures applied to ensure optimal crop health.

Table 4. The checklist for the most significant diseases that have been avoided and managed, as well as the chemical pesticides employed in research experiments

Date	Pesticide	Foliar spray	Soil application	Purpose of use
October 26.2022	Azoxystrobin 28% + Metalaxyl 10% Thiamethoxam 200gm/kg	✓	✓	Root rot protection
October 30.2022	Abamectin 1.8% + Hexythiaza 550%	✓	×	Protection against red mites
November 02.2022	Acetamiprid 20%w/w	✓	×	Kills red mites
November 08.2022	Metallic copper 21% + Mancozem 20%	✓	×	Kills whitefly
November 11.2022	Abamectin 2.2% + Biennale 43.2% + Bimectin45.4% + Clofentezine 50%	✓	×	Kills red mites
November15.2022	Metalic copper 21% + Mancozeb 20%	✓	×	Protection against mold
November 18.2022	Imidacloprid 20% s/c	✓	×	Kills whitefly
November 23.2022	Acequinocyl 15%	✓	×	Kills red mites
December 01.2022	Metalic copper 21% + Mancozeb 20%	✓	×	Protection against mold

Date	Pesticide	Foliar spray	Soil application	Purpose of use
December 05.2022	Bifenazate 48%, Abamectin 2.4% + Clofentezine 50%	✓	×	Kills red mites
December 08.2022	Penconazole 100gh EC + Cymoxanil 30% + Famoxadone 22.5%	✓	×	Protection against mold
December 10.2022	Metalic copper 21% + Mancozeb 20	✓	×	Protection against mold
December 13.2022	Thiocyclam hydrogen oxalate 50%	✓	×	*Tuta absoluta*
December 18.2022	Picarbutrazox 50%	✓	×	Protection against mold
December 28.2022	Metalic copper 21% + Mancozeb 20%	✓	×	Protection against mold
January 01.2023	Bifinazate 24% + Etozazole 11% sc	✓	×	Kills red mites
January 03.2023	Azoxystrobin 28% + Metalaxyl 10%	×	✓	Protection against mold
January 05.2023	Metalic copper 21% +Mancozeb 20%	✓	×	Protection against mold
January 08.2023	Hydroxyquinoline sulphate 50%w/w (500g/l)	×	✓	Protection against mold
January 10.2023	Iminoctadine tris + Propamocarb	✓	×	Protection against mold
January 12.2023	Acetamiprid 20% sp	✓	×	Kills whitefly
January 15.2023	Iminoctadine tris	✓	×	protection against gray mold
January 18.2023	Thiocyclam hydrogen oxalate 50%	✓	×	*Tuta absoluta*
January 23.2023	Spinosyn 22.8% sc	✓	×	kill Thrips
January 27.2023	Adepidyn 75gm/L + Difenoconazole 125/L	✓	×	Protection against mold
January 29.2023	Abamectin 2.2% + Bipennate 43.2% sc Pyridabin 20%wp	✓	×	Kills red mites
February 04.2023	Metallic copper 21%+ Mancozeb 20%	✓	×	Protection against mold
February 10.2023	Fosetyl - Al 50% + Folpet 25% +Cymoxanil 4%+ Iminoctadine tris	✓	×	Protection against mold
February 13.2023	Thiocyclam hydrogen oxalate 50%	✓	×	*Tuta absoluta*
February 17.2023	Fosetyle - Al 50% + Folpet 25%	✓	×	Protection against mold
February 20.2023	Natural vegetable canola rape seed oil 95%w/w + Pyflubumide 20%	✓	×	Kills red mites
February 23.2023	Methoxy fenozide 300g/l + Spentoram 60g/g + Acetamiprid 20% sp	✓	×	Kills thrips and red mites
March 05.2023	Formetanate + labmda-cyhaloth + Thiamethoxam 12.62%	✓	×	Kill Thrips
March 11.2023	Cyflumetofen 90% w/w +Hexythiazox 5%	✓	×	Kills red mites

✓: applied; ×: not applied

RESULTS AND DISCUSSION:

Data were collected before, during, and after cultivation and included a genetic trait survey of the three cultivars studied. The strength of each genetic trait was assessed using a numerical scale ranging from 1 to 5, where values closer to 5 indicate stronger trait expression and a more positive effect. Lower values represent weaker trait expression. The qualitative descriptor (weak) and (strong) correspond to low and high trait intensity, respectively, and were used to interpret the observed responses. Table 5 presents the genetic traits evaluated in this study.

Table 5. An illustration of the genetic characteristics that this study examined

Trait	Description
Vigor	Represents the general resistance of the tomato plant and the rigidity of the plant's body
The length of the Internodes	It is the distance between one node and the other on the stem and the branches of the plant. The smaller the distance between one node to another, the taller the plant stronger and more productive

Trait	Description
Totally green matter during the fruit coloring period (plant coverage /canopy)	The sum of the green material from the leaves and branches on the plant, it is preferable to remove the leaves nearby fruiting bunches to color the fruits better
Fruit setting	Flower setting is the first stage of fruit formation, and there are many factors that affect their hardening process such as temperature, humidity, etc.
Earliness of maturity	The ability of the plant to reach mature earlier in the harvesting process, because the early harvest greatly affects the marketing price
Fruit weight	Fruit weight plays an important role in the commercial market, as the preference for fruit weight differs from one market to another and from country to another
Number of fruits on clusters	Represents the final number of fruits on flower clusters, where the entire cluster is preferred to be complete or nearly complete
Fruit shape	The shape of tomato fruits is an important point from a marketing point of view, because there are different forms of tomato fruit
Uniformity	Degree of consistency in fruit size, shape, color and maturity with a plant and between clusters.
Ribbeness	The presence and expression of longitudinal ribs on the surface of the fruit. It is characterized by the depth, number, size and regularity of ribs.
Color intensity	It is the degree of redness and color intensity of the fruits of tomatoes had other colors
Firmness	Represents the hardness of the fruit, as it is a very characteristic importance and constitutes a sensitive point in the commercialization process, it is very important that the fruits should be solid
Resistance to cracking	In some varieties, the cracking characteristic of the fruits of tomato is common because it is a negative thing and greatly reduces the marketing price and increases the difficulty of their storage
Hormonal sensitivity	The tolerance of plants to hormones, sometimes the plant is affected by the amounts of hormones or the plant's response to the hormone
Yield rating	The rate or amount of crop harvest over time season for each of the varieties

Table 6 (a, b, and c) presents the numerical scores representing the strength of the traits evaluated for the tomato varieties included in this study. Table 6 (b) shows that Dafnis variety fruit shape is deep globe, ribbed, with dark color intensity, while SV4129 had oblate, smooth and dark traits. Finally, the variety of Newton is deep oblate, ribbed and dark. Table 6 (c) presents yield rates.

Table 6 (a). Varieties traits scoring (from 1 to 5)

Cultivar	Vigor	Internodes	Plant coverage	Fruit setting	1st Cluster in the top Setting & Size		Earliness
Scoring rank*	1 = weak 5 = strong	1 = long 5 = short	1 = low 5 = high	1 = low 5 = high	1 = low 5 = high		1 = later 5 = earlier
Dafnis	3	4	4	5	3	3	5
SV4129	5	3	5	5	2	2	3
Newton	5	3	3	5	4	4	5

*Number 1 when the trait is weak or low, and number 5 when the trait is strong or high.

Table 6 (b). Varieties fruit strength traits scoring (from 1 to 5)

Cultivar	Fruit weight	Fuits	Uniformity size	Uniformity cluster	Firmness	Cracking	Hormone sensitivity
Scoring rank*	grams	Per cluster	1 = low 5 = high	1 = low 5 = high	1 = low 5 = high	1 = low 5 = higher	1 = low 5 = higher
Dafnis	200	5	5	5	3	2	1
SV4129	220	5	5	5	5	2	2
Newton	180	7	3	5	5	1	1

*Number 1 when the trait is weak or low, and number 5 when the trait is strong or high.

Table 6 (c). Varieties yield rating traits scoring (from 1 to 5)

Cultivar	Yield rating	
Scoring rank*	1 = low 5 = higher	Total (kg per plant)
Dafnis	3	3.45
SV4129	4	3.65
Newton	5	4.26

*Number 1 when the trait is weak or low, and number 5 when the trait is strong or high.

Harvesting was conducted at different times for each variety, with intervals between harvests ranging from 8 to 11 days. Table 7 illustrates the harvested crop amounts, harvesting dates, and total yield obtained on each harvesting date from the three fully operational greenhouses. The recorded data and comparative yield analysis among the three varieties across harvesting dates revealed substantial differences in growth and productivity parameters. Both varieties of Dafnis and SV4129 exhibited lower yields compared with the control one, Newton. Since temperature and atmospheric conditions under protected cultivation were uniform and maintained at similar levels across all greenhouses, the observed yield differences are most likely attributable to varietal/genetic characteristics rather than environmental variation. Among the varieties, Dafnis produced the lowest yield, followed by SV4129, which showed moderate yield performance, whereas Newton consistently demonstrated superior yield productivity.

Table 7. The harvest dates and corresponding yields (kg) for all plants among three cultivars

Cultivar	20.01.2023	29.01.2023	05.02.2023	15.02.2023	23.02.2023	03.03.2023	10.03.2023	15.03.2023	20.03.2023
Dafnis	785	640	790	690	630	510	690	270	160
SV4129	835	900	870	780	710	600	360	185	230
Newton	920	870	970	860	660	710	870	346	185

Figure 1 displays total harvests recorded for the Newton variety, with a total yield of 6206 (up to 6391 kg) (38%). This was followed by the SV5129 cultivar, which produced 5470 kg (32%). In contrast, the Dafnis cultivar exhibited the lowest productivity, with a total yield of 5165 kg (30%).

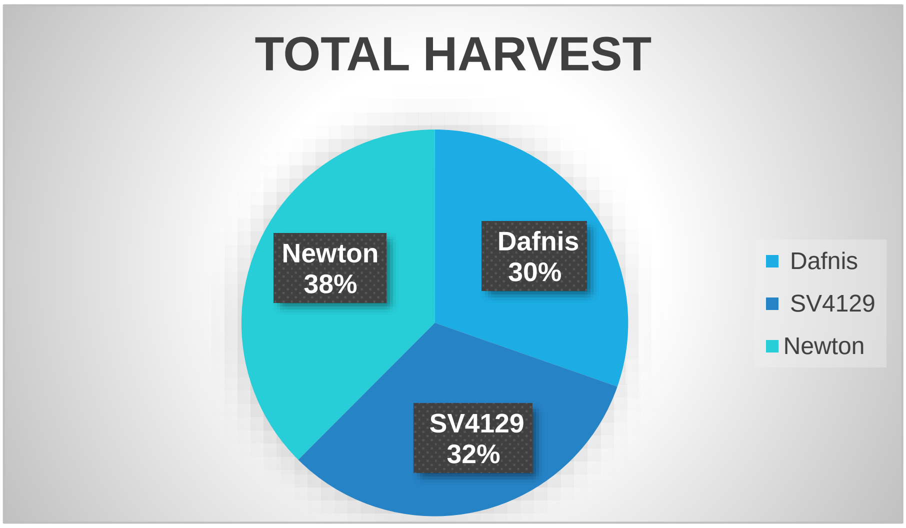

Figure 1. Tomato production per cultivar across different harvesting periods

This study revealed clear genetic differences among the tomato varieties Dafnis, SV4129, and Newton grown under protected cultivation in the Jordan Valley. Under uniform greenhouse conditions, Newton produced the highest yield, indicating strong reproductive efficiency and suitability for high-input systems with effective virus management/control. Dafnis and SV4129 showed lower yield potential but greater resistance to fungal pathogens and viral diseases, offering improved stability under higher disease pressure. These findings highlight the importance of variety selection and targeted management for optimizing greenhouse tomato production.

CONCLUSION

The primary objective of this study was to compare the genetic traits of selected tomato varieties in relation to their resistance to major soil-borne pathogens and viral diseases, including *Pythium*, *Fusarium*, Tomato Yellow Leaf Curl Virus (TYLCV), and Tobacco Mosaic Virus (TMV). The results demonstrated clear varietal differences in yield and yield components, disease tolerance, and viral resistance. The Dafnis variety exhibited high tolerance to soil-borne diseases and fungal pathogens (*Pythium* and *Fusarium*), along with strong tolerance to both TYLCV and TMV. The SV4129 variety showed good tolerance to *Pythium* and *Fusarium* and high tolerance to TYLCV; however, it was susceptible to TMV. Finally, the Newton variety demonstrated high tolerance to soil-borne diseases (*Pythium* and *Fusarium*), but it was susceptible to TYLCV and moderately susceptible to TMV. Despite its vulnerability to viral infections, Newton produced the highest and most vigorous yield under protected cultivation conditions. Consequently, this variety is recommended for greenhouse production in Jordan Valley, particularly when effective viral control measures are into practice. However, in situations where virus management is inadequate, cultivation of the Newton variety is not advised due to its susceptibility to viral diseases. Overall, the findings highlight the importance of selecting tomato varieties based on disease pressure, and available management practices. Adopting the appropriate variety with the appropriate pest control can significantly enhance productivity and reduce disease-related losses under protected cultivation systems.

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