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ORIGINAL RESEARCH

Evaluation of Different Exotic Onion Germplasm for Yield and Agronomic Traits

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ABSTRACT: Onion (*Allium cepa* L.) is an important cash crop with significant economic potential for farmers in Pakistan. However, limited information is available regarding the performance of commercial onion genotypes under the agro-climatic conditions of district Charsadda, Khyber Pakhtunkhwa. To address this gap, an experiment was conducted during 2018–2019 to evaluate the performance of four onion genotypes and assess their suitability for cultivation in this region. The genotypes including Macarena, Capri F1, Red Queen, and Super King, were transplanted in a randomized complete block design (RCBD) with three replications. The results indicated non-significant differences among genotypes for most of the studied traits. However, some genotypes showed superior performance in specific parameters. Macarena produced the longest leaves (62.1 cm), while Red Queen had the shortest (53.8 cm). The highest leaf diameter (2.3 cm) and number of leaves per plant (10.0) were recorded in Capri F1. Macarena had the largest bulb diameter (7.52 cm), while Super King had the smallest (6.92 cm). Uniform bulb maturity (100%) was observed in Macarena and Capri F1, whereas Super King showed only 80% maturity. Macarena also produced the heaviest bulbs (239 g), in contrast to Super King (162 g). The number of axils per bulb ranged from 1.0 in Capri F1 to 2.0 in Macarena. Red Queen exhibited the highest pungency (3.7), while Macarena was the least pungent (2.0). Regarding post-harvest performance, Red Queen and Macarena showed the least reduction in bulb weight after 15 days of storage (8.7%), while Capri F1 and Super King had the highest reduction (12.0%). After 30 days, Super King had the lowest weight loss (2%), whereas Macarena recorded the highest (4%). In conclusion, the results suggest that Macarena and Capri F1 outperformed the other genotypes in key agronomic and post-harvest traits. These findings support the feasibility of onion cultivation in district Charsadda and highlight its potential as a profitable gap-filling crop for local farmers.

KEYWORDS: Mung bean varieties, biological stress, growth, plant density, yield, chemical content

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1. Introduction

Onion (Allium *cepa* L) belongs tothe family *Liliaceae or Amaryllidace (amaryllis)*, is one of the most important cool season vegetable group of crops worldwide (Wassie et al., 2022). The genus *Allium* comprises over 750 species which can be found throughout the tropical, temperate and sub-temperate regions of the world (Ddamulira et al., 2019). It is widely grown herbaceous biennial vegetable crop with cross pollinated and monocotyledonous behavior having

diploid chromosomes number 2n=16. The plant has shallow adventitious fibrous roots (Gelaye et al., 2024) bulb, and tubular leaves. The stem grows 100–200cm tall during the second year of the plant's life. The green leaves of the plant are an extension of the outer food storage leaves. The inflorescence is umbel-like and develops from a ring-like apical meristem. The umbel is the aggregation of flowers at various stages of development, and it contains 200–600 small individual flowers, although this number can range from50 to 1000 (Thomas, 2022). It is composed of white or greenish-white small flowers which grow at the tip of the stem in the second year of the plant. The onion bulb ranges in shape from flat to globular to oblong, and the onions are usually of three colors: red, white, and yellow (Greeshma et al., 2020).

Onions are grown in every part of the world where plants are cultivated and can be grown from seed transplant or sets for both green and dry bulbs (Anjum et al., 2019). It shows great variation in many characteristics such as size, color, shape and pungency (Teshika et al., 2018). The pungency of the onion bulbs is due to the presence of a volatile oil that is allylpropyl disulfide (Bilal et al., 2016). These have diuretic properties and are beneficial to the digestive tract. Onions are good for eyes, act as a heart stimulants and useful as ant rheumatic remedies. Onions exhibit particular diversity in the eastern Mediterranean countries, through Turkmenistan, Tajikistan to Pakistan and India, which are the most important sources of genetic diversity and believed to be center of origin (Ochar and Kim, 2023). However, the leading onion producer countries are China, India, USA and Turkey.

Onions have been cultivated globally, in at least 175 countries, for around 5000 years. Total area of world under onion cultivation is 1.64 million hectares while the total production of onion is 86.34 million tones (FAO, 2023). In Pakistan its area under cultivation is 135.5 thousand hectares with a production of 13600 kg ha^{-1} during 2022-23 (FAO, 2023). Onion is one of the oldest bulb vegetables in continuous cultivation dating back to at least 4000 BC (Ali et al., 2019). Onion are grouped into short days and long days depending on the day length requirements (Atif et al., 2020). Onions are a good source of certain minerals, vitamins and carbohydrates. The bulb contains carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and energy (38 cal.) (Padula et al., 2022). Onions are grown mainly as food materials however onion has medicinal properties and has been used for the treatment of various ailments such as skin diseases, ear pain, heart attack and strokes. Onion is an important vegetable crop whose distinctive flavor is appreciated by people throughout the world. One of the advantages of onion is that the bulbs can be harvested and sold either 'green' in salads, while the mature bulbs are cooked or eaten raw as a vegetable (Shishkina et al., 2019).

A cultivar crop performs differently under different agro-climatic conditions and various cultivars of the same species grown even in the same environment give different yields as the performance of a cultivar mainly depends on the interaction of genetic makeup and environment (Alemu et al., 2022). Onion is a winter season cash crop and grown

throughout Pakistan. The production of onions in Pakistan is very low which can only meet 18% of the local demand and therefore, the country depends on import of dry (mature) to meet the local demand of onion. On good soils, yields of over 60 t/ha are possible. However, 40 t/ha is far below the world average onion yield. The low productivity of vegetables including onion in Pakistan is attributed to a number of yield reducing factors which include among others low yielding varieties, harsh climate and poor soils (Khokhar, 2017). In Pakistan winter is too short but temperatures can touch to the lowest of -4°C.On the other hand, very high temperatures in summer season which sometimes touches to 45°C. As onion requires long winter for proper growth and development of bulb, it becomes very difficult to produce good yield. Apart from the good management and cultural practices, development of new varieties and evaluation of the available onion varieties are the sustainable strategies to improve the productivity and production of onions (Zahra and Kambiz, 2023).

The evaluation of the existing and available onion varieties for their adaption and productivity in the climatic conditions of Pakistan is a faster way to improve the onion production. The farmers choose onion variety for planting depending on a number of factors which include production potential, market demand, regional adaptability and availability of seeds and their prices. Although several high yielding varieties and hybrids have been introduced during the last decades, there is a potential need for them to be evaluated in the agro-climatic conditions of Khyber Pakhtunkhwa especially in district Charsadda. Most vegetable cultivar trials including onion focus on yield and quality attributes and are implemented on research stations (Younas et al., 2022). However, yield performance of varieties has hardly been evaluated on on-farm conditions in district Charsadda. The purpose of the on-farm variety evaluation trials was to identify promising onion varieties and thus provide up-to-date variety recommendations for the vegetable growers. Before any final variety recommendation is made, it is extremely important to evaluate the varieties on farmer's field for their adaptation and productivity performance. The objective of the on-farm trials was; 1) to evaluate the yield performance and productivity of promising germplasm of onion on farm fields. 2) To identify the best genotype for farmers based on yield and shelf life performance.

2. Material and methods

2.1. Experimental location and design

A research study to evaluate different onion exotic germplasm for yield and agronomic traits was carried out at experimental area of Bacha Khan University, Charsadda (Figure 1) during sowing season 2019. Figures 2 and 3 show the annual temperature and rainfall patterns, respectively, during the onion growth period. Four onion genotypes namely Capri F1, Red Queen, Macarena and Super King were transplanted to the open field in randomized complete block design (RCBD) having three replications. Each plot comprised of four rowsof5 meter length. Row to row length and plant to plant spacing was kept at 25 cm and 30 cm, respectively. The surface method was used for irrigating the onion crop.

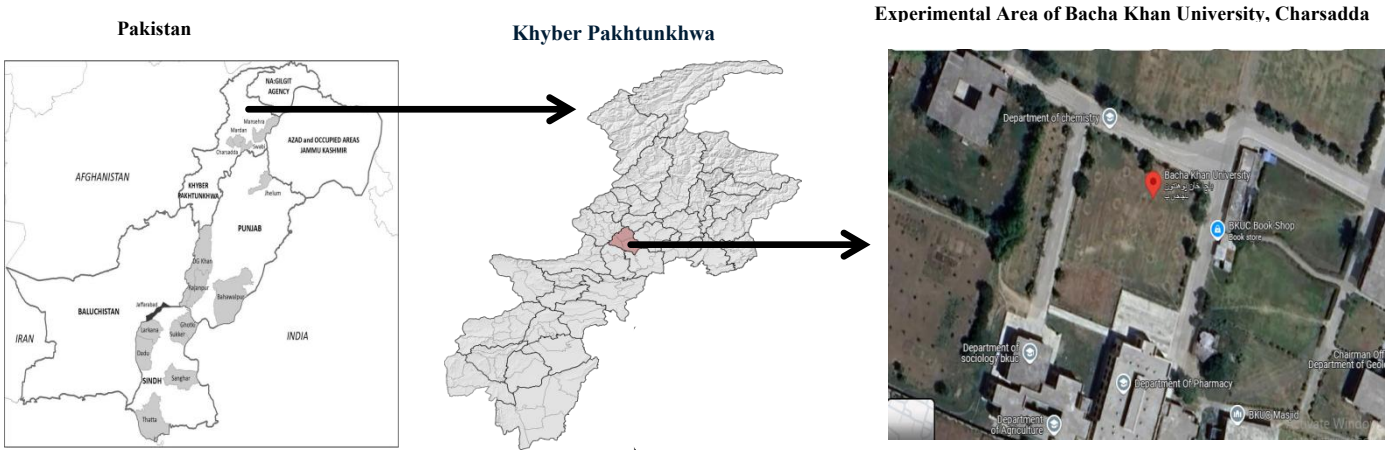

Figure 1. Map indicating Experimental Area of Bacha Khan University, Charsadda

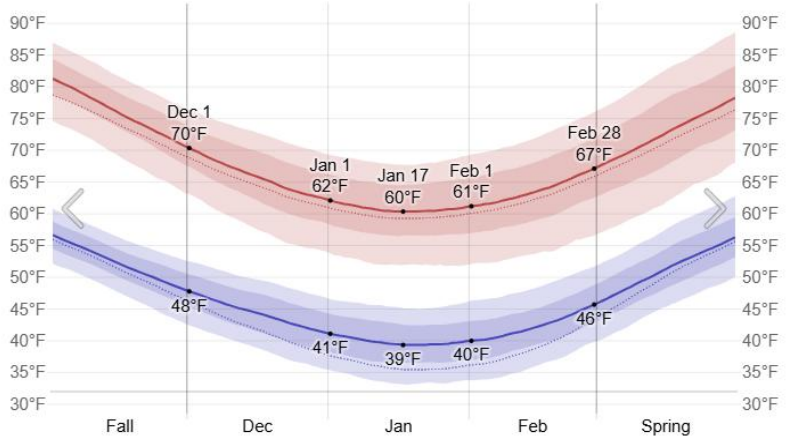

Figure 2. Annual temperature during growth period of onion genotypes

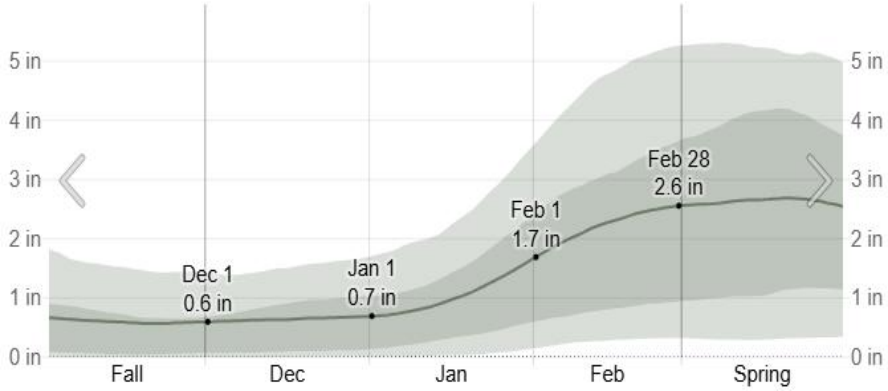

Figure 3. Annual rainfall during growth period of onion genotypes

All recommended cultural practices were adopted from transplanting till harvest. Due to zero disease and pest incidence, no farm chemicals were applied. All genotypes were harvested once as per their maturity stage (80%).

2.2. Measurement

2.2.1 Growth attributes

The length of the onion leaf was measured in centimeters (cm) from the base, where it emerges from the bulb, to the tip using a standard measuring scale. The width of the leaf was recorded at its widest point, corresponding to the area of maximum thickness (cm). Leaf area (LA) is a critical indicator of the plant's capacity for photosynthesis. A larger leaf area enhances light interception, thereby promoting improved photosynthetic efficiency, vigorous vegetative growth, and ultimately higher bulb yield. In this study, leaf area was estimated using equation 1.

$$\text{Leaf } Area = \frac{\text{Leaf Width}}{\text{Leaf Length}} \times 0.75 \quad \text{Equation (1)}$$

where 0.75 is a correction factor that accounts for the semi-cylindrical shape of onion leaves. The leaf width-to-length ratio was calculated using equation 2.

$$\text{Leaf Ratio} = \frac{\text{Leaf Width}}{\text{Leaf Length}} \quad \text{Equation (2)}$$

The number of leaves was counted once the onion bulbs reached full maturity. The diameter of the onion bulb was measured at the point of maximum thickness using a Vernier caliper. The bulb volume, measured in cm^3, can provide insights into the overall bulb development. It was calculated as

Bulb Volume=3/4 π (Bulb Diameter /2)^3

The bulb shape index was recorded as the ratio of bulb volume to bulb weight. Total leaf area per plant was the product of number of leaves and average leaf area.

2.2.2. Yield attributes

Each individual onion bulb was weighed using an electronic weighing scale to ensure precise measurements. The weight of the bulbs was recorded in grams. Axils are the points on the onion bulb from which the leaves emerge. To assess the number of axils, the bulb was carefully cut horizontally, and the number of axils present in each bulb was counted. Axil density (cm^2) was calculated by dividing the leaf area to the number of axils. The onion bulbs were phenotypically observed in each entry, and their maturity was assessed and rated on a scale from 1 to 5. A rating of 1 indicated no uniformity in maturity, while a rating of 5 represented complete uniformity in bulb maturity. The observations were recorded accordingly for each plant entry.

2.2.3 Quality attributes

Pungency levels in the onion bulbs were observed and rated on a scale from 1 to 5. A rating of 1 indicated very mild pungency, while a rating of 5 represented highly pungent bulbs. Four bulbs from each genotype were stored at room temperature for a period of 15 days. After this duration, any weight loss in the bulbs was carefully measured and recorded as a percentage, providing insight into the storage tolerance of each genotype. The weight of the same bulbs, which had been stored at room temperature, was recorded again after 30 days of storage. The reduction in weight was calculated and expressed as a percentage, with the average weight loss across all bulbs noted for further analysis.

2.3. Statistical analysis

Inferential and descriptive statistical methods were applied for data analysis using STATISTIX 8.1 software. A two-way analysis of variance (ANOVA) was performed to evaluate and rank the genotypes based on various traits utilizing Panse and Sukhatme (1984).

3. Results

The analysis of the data revealed that the performance of different genotypes are well irrespective of their differences in genetic make, this also indicated that the environment of Charsadda can be exploited to grow onion in the locality, so that the farmers may get maximum benefits from farming. The performance of different genotypes is discussed below.

3.1. Growth attributes

Non-significant differences among the genotype were observed when data was analyzed for different growth parameters (Table 1). This indicate that the uniform performance of all germplasm at the farm field. It is evident from table 1 that maximum number of leaf length was observed for Macarena (62 cm) and minimum number of leaf length was observed for Red Queen (53.8 cm).Also average minimum number of leaf width was evident for Macarena and Super king (2.1 cm), whereas maximum number of leaf width was observed for Capri F1 (2.3 cm).These results are against the findings of (Ali et al., 2019) who revealed significant differences among the evaluated germplasm. Maximum and minimum leaf area was observed for Capri F1 and Red Queen having values of 104.7 and 92.95 cm^2, respectively.

The data for leaf ratio varied between 0.041 and 0.034 attained by Red Queen and Macarena, respectively. Similarly, maximum number of leaves was attained by Capri F1 (10.0) whereas minimum number of leaves was evident for Red Queen (9.2). Highest (470.93 cm^3) and lowest (337.68 cm^3) bulb volume was observed for Macarena and Super King, respectively. The data for bulb shape index (value > 1.5) revealed that almost all genotypes has more oval or elongated shape. Minimum bulb diameter was observed for Super king (6.92 cm) table 2 followed by Capri F1 whereas maximum number of bulb diameter was evident for Macarena (7.52 cm).

Table 1.Changes in growth attributes of different exotic onion germplasm.

Genotypes	Leaf Length (cm)	Leaf Width (cm)	Leaf Area (cm^2)	Leaf ratio	No of leaves
Capri F1	58.0±1.2a	2.3±0.12a	104.70±4.3a	0.040±0.01a	10.0±0.02a
Red Queen	53.8±1.5b	2.2±0.09b	92.95±5.7b	0.041±0.01a	9.2±0.03b
Macarena	62.0±1.3a	2.1±0.13c	102.25±3.3a	0.034±0.01b	9.4±0.10b
Super King	57.9±1.4ab	2.1±0.11c	95.49±4.6b	0.036±0.01b	9.8±0.08b
LSD	4.6	0.43	5.21	0.021	1.01

Note: LSD —Least Significant Difference at $p < 0.05$; ± values represent standard deviation (SD); different letters indicate significant differences at $p < 0.05$ according to LSD test.

Table 2.Changes in yield related attributes of different exotic onion germplasms.

Genotypes	Bulb Volume	Bulb shape index	Bulb diameter(cm)	Total leaf area per plant (cm^2)	Bulb weight(g)
CapriF1	391.37±33.2c	2.08±0.10b	7.18±0.08c	1048±34a	188±24b
Red Queen	420.49±52.1b	2.35±0.09a	7.31±0.01ab	855±67c	178.6±31b
Macarena	470.93±48.9a	1.96±0.15c	7.52±0.04a	961±45b	239.33±28a
Super King	337.68±40.7d	2.08±0.11b	6.92±0.10c	936±56b	162.3±47bc
LSD	44.5	0.28	0.71	104	56.2

Note: LSD —Least Significant Difference at $p < 0.05$; ± values represent standard deviation (SD); different letters indicate significant differences at $p < 0.05$ according to LSD test.

Table 3. Changes in quality attributes of different exotic onion germplasms.

Genotypes	No of axil	Axil Density per cm^2	Uniform maturity	Pungency Pyruvic acid µmoles/g	Weight reduction (%) after 15 days	Weight reduction (%) after 30 days
CapriF1	1±0.15c	104.7±17a	5.0±0.21a	2.3±0.6b	12±1.8a	2.3±0.12c
Red Queen	1.3±0.25b	71.5±27b	4.5±0.14b	3.7±0.3a	8.7±2.3b	3±0.03b
Macarena	2.0±a1.01a	51.1±11c	5.0±0.20a	2.0±0.3b	8.7±1.9b	4±0.14a
Super King	1.3±1.2b	73.4±9b	4.0±0.24ab	2.3±0.4b	12±2.1a	2.0±0.61c
LSD	0.81	47.2	1.3	0.57	2.7	2.2

Note: LSD —Least Significant Difference at $p < 0.05$; ± values represent standard deviation (SD); different letters indicate significant differences at $p < 0.05$ according to LSD test.

Similarly, Capri F1 revealed highest total leaf area per plant attaining the value of 1048 cm^2 whereas Red Queen attain minimum value for this parameter (855 cm^2).

3.2 Yield Attributes

Non-significant differences among the germplasm were observed regarding yield and yield related attributes (Table 3). Maximum average bulb weight was recorded for Macarena (239.3) whereas minimum bulb weight was evident for Super king followed by red queen and Capri F1 (162.3). Similarly, maximum numbers of axil were observed by Macarena (2.0) while Capri F1 revealed minimum (1.0) number of axil $bulb^{-1}$. Maximum value for axil density per cm^2 (104.7) was observed for Capri F1 whereas minimum value for the same parameter was evident for Macarena (51.1 cm^2). Capri F1 and Macarena revealed 100 % uniform bulb maturity whereas as least uniformity in bulb maturity 80 % was evident for Super king (table 4). (Mushtaq et al., 2013).

3.3 Quality attributes

The data revealed significant differences among the genotypes for quality attributes as

well (Table5). When pungency was taken into account Red queen revealed to be most pungent^{-1} (3.0) whereas germplasm Macarena proved to be least pungent (2.0). Maximum reduction in weight at room temperature after 15 days was evident for Capri F1 (12%) and Super king whereas minimum 8.7% reduction in weight was observed for Red queen and Macarena. Maximum reduction in weight after 30 days was obtained for Macarena (4.0 %) whereas minimum reduction after 30 days was recorded for super king (2.0 %).

4. Discussion

The study's findings showed that, regardless of the germplasm development origin, onions perform better in the Charsadda locality. The climate makes it easier for Charsadda's impoverished farmers to grow onions as a cash crop. By mid-December, the farmers typically had finished harvesting their sugarcane crop. Since it was not the right time to plant wheat, they can grow onions and earn a lot of money instead of abandoning their field for a few months. The leaf length performance of the various cultivars showed better performance than what Ali et al. (2019) had previously reported. In contrast to the current study, Ali et al. (2019) reported a maximum leaf length of 47.6 cm. The genetic variation among the various onion cultivars may be the cause of the improvement in leaf length. The slight variations observed in the leaf width of various onion cultivars may be due to the genes that comprise those cultivars or to the weather, which can cause the leaves of some cultivars to become thinner. Since leaves are the primary organ that produces food, their quantity had an impact on the crop's development. In contrast to our findings, earlier research found that onions have more leaves.

The leaf area is a critical measure of the plant's capacity for photosynthesis. Larger leaf area allows for more efficient photosynthesis, promoting better growth and higher bulb yield. Similarly, the ratio helps assess the morphology of the leaves. A higher ratio might indicate long, narrow leaves, while a lower ratio could show broader leaves. This can help in understanding the plant's adaptation to its environment.

The bulb volume can provide insights into the overall bulb development. Larger volumes generally indicate better growth conditions and greater yield potential. The bulb shape index helps to assess the shape and density of the bulb. It’s important for understanding whether the bulb’s weight is proportional to its volume and can be an indicator of how well the bulb is filling out. Bulb diameter is influenced by plant density; the smaller the bulb, the higher the plant density. Compared to the vegetative stage, onions are more vulnerable to water stress during bulb formation and enlargement (Khokar, 2017).

Total leaf area per plant gives a broader picture of the photosynthetic capacity of the plant. A larger leaf area typically means the plant can photosynthesize more effectively, leading to better overall growth.

For the majority of crops, early and consistent maturity is necessary. Because of the decline in the plant population, we noticed a notable delay in maturity. The outcome made it clear that most of the germplasm reached uniform maturity. According to Gebremeskel et al. (2016), there were significant variations in onion varieties as well as genotypic variations in parameters

associated with yield and growth. Researchers thought that bulb weight increased significantly when the number of plants decreased. The bulb weights significantly more than other genotypes because Macarena has fewer plants. These outcomes are in line with those of Hidayatullah et al. (2018), who found that plants cultivated at higher densities matured more quickly. Inappropriate handling of bulbs during or after harvest could cause mechanical damage, reducing their quality and reducing their shelf life. This is due to the fact that internal or external injury results in storage diseases and excessive water loss. After curing, handling is particularly crucial since extremely dry exterior scales are more likely to rip and get damaged from rubbing off. Onion bulb quality during storage is mainly impacted by water loss, sprouting, roots, and chemical composition changes. It has been noted that controlled atmospheres extend the shelf life of cultivars that are only kept for brief periods of time in regular atmospheres, as well as cultivars with great storage potential (Poldma et al. 2011). According to Sharma et al. (2014), after 4–8 weeks, foods stored at room temperature and 60–80% relative humidity (RH) had higher levels of quercetin, phenolics, flavonoids, and antioxidants as well as higher antioxidant activity. Nevertheless, the food lost weight and sprouted, lowering the quality hence the likeness of the food decreased.

5. Conclusion

Based on these results and discussion it could be concluded that Macarena and Capri F1 performed better than other genotypes in terms of leaf length, bulb diameter, bulb weight, uniformity of maturity, and storage tolerance. Therefore, it is recommended that these genotypes be considered for further cultivation in the Charsadda locality. Furthermore, breeding programs to improve onion yields and post-harvest quality should be encouraged. Future research should also explore factors such as pest resistance and adaptability to various environmental conditions to further enhance the performance of Macarena and Capri F1 in different growing regions.

Author Contribution

Conceptualization Formal Analysis: Syed Majid Rasheed, Writing-Original Draft Preparation: Osama Younas, Writing-Review and Editing: Hasnain Ahmad , All authors have read and agreed to the published version of the manuscript.

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REFERENCES

Alemu, D., Kitila, C., Garedew, W., Jule, L., Badassa, B., Nagaprasad, N., Seenivasan, V., Saka, A., Ramaswamy, K. Growth, yield, and yield variables of onion (Allium Cepa L.) varieties as influenced by plant spacing at Dambi Dollo, Western Ethiopia.(2022). Scientific Reports, 12(1), p.20563. https://doi.org/10.1038/s41598-022-24993-x

Ali M, Ayub, G., Khan N., Khan M.W, Naeem A, Khan K, Rehman S., Afzal M., Rehman M., Ullah R. Response of organic

manures to the growth of onion cultivars in Peshawar valley. Pure and Applied Biology. (2019) 8(2): 1374-1384. https://doi.org/10.19045/bspab.2019.80078

Anjum, M.A., Muhammad, H.M.D., Balal, R.M., Ahmad, R. Performance of two onion (Allium cepa L.) cultivars under two different planting systems in calcareous soil. Journal of Horticultural Science and Technology (2019): 2(2), pp.54-59. https://doi.org/10.46653/jhst190202054

Atif, M.J.; Ahanger, M.A.; Amin, B.; Ghani, M.I.; Ali, M.; Cheng, Z. Mechanism of Allium Crops Bulb Enlargement in Response to Photoperiod: A Review. International Journal of Molecular Sciences (2020). 21, 1325. https://doi.org/10.3390/ijms21041325

Bilal, A., Ayub, M.A., Mushtaq, A., Saeed, A., Azeem, M.W., Khaliq, M. and Rezgui, M. ONION: A review of its global benefits to health. International Journal of Chemical and Biochemical Sciences (2016). 10(2016):111-115

Ddamulira, G., Kalali, F., Maphosa, M. Yield and Storage Performance of Onion (Allium cepa L.) Genotypes under in situ and ex-situ Conditions. International Journal of Plant & Soil Science, (2019). 30(4), pp.1-7. https://doi.org/10.9734/ijpss/2019/v30i430182

FAO (2023). Food and Agriculture Organization. Available online at: https://www.fao.org/faostat/en/#data/QCL.

Gebremeskel H, Abebe H, Jaleto K, Biratu W Genotypic difference in growth and yield related traits of onion (Allium Cepa L.) varieties at southern tigray. Current Research in Agricultural Sciences. (2016). 3: 16-21. https://doi.org/10.18488/journal.68/2016.3.2/68.2.16.21

Gelaye, Y., Nakachew, K., Ali, S., A Review of the Prospective Effects of Spacing and Varieties on Onion Yield and Yield Components (Allium cepa L.) in Ethiopia. The Scientific World Journal (2024). 2024(1), p.2795747.https://doi.org/10.1155/2024/2795747

Greeshma, K.P., Muthulingam, S., Thamizselvi, R., Venkatamani, G.P. Phytochemical analysis and a review on biological importance of Allium cepa. L. GSC Advanced Research and Reviews (2020). 2(2), pp. 018-024. https://doi.org/10.30574/gscarr.2020.2.2.0004

Hidayatullah, Khan, H. A., Jillani, G. Response of two newly selected onion strains at different plant populations. Horticulture International Journal. (2018). 2 (1),17- 19. https://doi.org/10.15406/hij.2018.02.00019

Khokhar, K. M. Environmental and genotypic effects on bulb development in onion - a review. The Journal of Horticultural Science and Biotechnology (2017). 92(5), 448-454. https://doi.org/10.1080/14620316.2017.1314199

Mushtaq S, Amjad M, Ziaf K, Cheema KL, Raza MA, Hafeez OBA. Productive and qualitative evaluation of onion cultivars under agro-climatic conditions of Faisalabad. Pakistan Journal of Agriculture Science (2013) 50: 199-203

Ochar, K., Kim, S.-H. Conservation and Global Distribution of Onion (Allium cepa L.)

Germplasm for Agricultural Sustainability. Plants (2023). 12(18), 3294. https://doi.org/10.3390/plants12183294

Padula G, Xia X, Hołubowicz R. Welsh Onion (Allium fistulosum L.) Seed Physiology, Breeding, Production and Trade. Plants. (2022). 11(3):343. https://doi.org/10.3390/plants11030343

Panse, V. G., Sukhatme, P. V. Statistical methods for agriculture workers. Indian Council of Agricultural Research, New Delhi, India (1984).

Poldma, P.; Moor, U.; Merivee, A.; Tonutare, T. Effect of controlled atmosphere storage on storage life of onion and garlic cultivars. Acta Horticultura. (2011). 945, 63-70. https://doi.org/10.17660/ActaHortic.2012.945.7

Sharma, K.; Asnin, L.; Ko, E.Y.; Lee, E.T.; Park, S.W. Phytochemical composition of onion during long-term storage. Acta agriculture Scandinavica. (2014). 65, 150-160. https://doi.org/10.1080/09064710.2014.983151

Shishkina, Y.V., Zharkova, S.U., Malykina, O.U. Welsh onion (Allium fistulosum) variety 'Premyera' for conditions of the south of western Siberia. Russ. Veg. (2019). 45, 65-67. https://doi.org/10.18619/2072-9146-2019-1-65-67

Thomas, B., Crop Development-Onion. In Edible Alliums: Botany, Production and Uses (2022). (pp. 51-67). GB: CABI.

Teshika, J. D., Zakariyyah, A. M., Zaynab, T., Zengin, G., Rengasamy, K. R., Pandian, S. K., Fawzi, M. M. Traditional and modern uses of onion bulb (Allium cepa L.): a systematic review. Critical Reviews in Food Science and Nutrition. (2018). 59(sup1), S39-S70. https://doi.org/10.1080/10408398.2018.1499074

Wassie, W.A., Assegahegn, G.F., Tsegaye, B.A., Mekonnen, A.B. Evaluation of Intrarow Spacing on Growth and Yield Performance of Four Onion (Allium cepa L.) Varieties in Beyeda District, North Gondar, Ethiopia. Advances in Agriculture (2022). 2022(1), p.9408607. https://doi.org/10.1155/2022/9408607

Younas, M., Hussain, K., Ghaffar, A., Atiq, M., Hussain, N., Abbas, W., Khan, MA, Nadeem, M., Irshad, M., Khan, NA, Zubair, M. Assessment of Genetic Variability in Onion against Purple Leaf Blotch Disease under Field Conditions and its Management. Sarhad Journal of Agriculture (2022). 38 (4), pp.1273-1278. https://doi.org/10.17582/journal.sja/2022/38.4.1273.1278

Zahra K., Kambiz M. A review of the effects of onion varieties with different photoperiod requirements and their origin on selecting the suitable sowing date. International Journal of Vegetable Science (2023). 29:5, pages 444-455 https://doi.org/10.1080/19315260.2023.2248614

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