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Research Article

Effect of Organic Potash on Morpho-Physiological Traits, Yield, and Quality of Onion (*Allium cepa* L.) Cultivars under Field Conditions

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ABSTRACT

A field experiment was conducted at the University of Agriculture Peshawar (2018) to evaluate the effect of organic potash on the growth, yield, and quality of onion cultivars. The study followed a randomized complete block design with a split-plot arrangement. Organic potash derived from BSCR Organic Compost (Peshawar) was applied at four levels (0, 80, 100, and 120 kg ha^{-1}) two weeks before transplanting, while three onion cultivars (Swat-1, Bara Local, and Nasik Red) were tested. The potassium treatments were controlled with organic potassium being applied as sulphate of potash, but the potash was applied as organic potassium through NKS (4% N, 30% K, and 1% S) two weeks prior to transplanting. The parameters measured were leaf area per plant (cm^2), number of leaves per plant, bulb diameter (cm), neck diameter (cm), bulb weight (g), firmness (kg cm^{-2}), and bulb yield (t ha^{-1}). The results showed a significant positive effect of organic potash on all measured parameters. The highest plant height (63.92 cm), bulb diameter (6.47 cm), bulb weight (129.47 g), neck diameter (0.87 cm), bulb yield (23.46 t ha^{-1}), and firmness after 180 days of storage (6.3 kg cm^{-2}) were observed with 120 kg ha^{-1} of potash, demonstrating that higher doses improve onion growth and productivity. Results at 100 kg ha^{-1} were similar, indicating this level is also effective. Among the cultivars, Swat-1 performed best, producing the tallest plants (71.57 cm), the highest number of leaves per plant (11.75), largest leaf area (1206.7 cm^2), greatest bulb diameter (6.66 cm), heaviest bulbs (147.76 g), largest neck diameter (0.89 cm), highest bulb yield (23.05 t ha^{-1}), and highest total soluble solids (TSS, 12.01 °Brix). Overall, the graphical abstract highlights that the use of organic potash from a local compost source can sustainably improve onion productivity, with 100 kg ha^{-1} as the recommended rate and cv. Swat-1 as the most suitable cultivar under Peshawar conditions.

Keywords: Bulb diameter, Bulb yield, Onion (*Allium cepa* L.), Organic potash, Potassium fertilization, Sustainable nutrient management

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INTRODUCTION

Allium cepa, commonly known as onion, belongs to the family Alliaceae. The onion bulb, which serves as an underground storage organ, contains axillary buds enclosed by fleshy, scaly leaves (Ranjitkar, 2003). These inner leaves are thickened to characterize the development of this bulb. Some of the Allium species perform very well as food crops of major importance (Kiple, 2000; Kane, 2006). Onions are also characterized by hollow cylindrical leaves, which are arranged alternately, parallel veins and base of the leaf which are fleshy and sheathing developing out of the underground stem (Ranjitkar, 2003). These basal sheaths form a protective tube around the growing point, which protects the apex of the young shoot and developing leaves. According to Ross (2001), new leaves emerge from the central sheath, and the leaves possess tubular blades that are slightly flattened on one side, hollow, and closed at the tip. Ranjitkar (2003) reported that the underground stem of onion develops into a tunicate bulb consisting of a shortened stem with auxiliary buds, surrounded by fleshy inner scales and dry outer scales. The apical meristem gives rise to a terminal inflorescence, which is ring-shaped. The onion plant normally produces one or more scales that extend well above the foliage and may reach heights ranging from 30 cm to over 100 cm. Each scape bears a spherical umbel, 2–5 cm in diameter, which develops into an aggregate of flowers at different stages of development. Typically, the umbel contains 200–600 small flowers, although the number may range from as few as 50 to as many as 1,000 depending on the cultivar and environmental conditions (Ross, 2001).

Onion is one of the most widely cultivated vegetables and has been used both as a seasoning and as a vegetable throughout history. It is consumed in both raw and cooked forms and is commonly referred to as the “Queen of the Kitchen” due to its high value in terms of taste, flavor, and aroma. The origin of onion and garlic dates back to early human civilization. Both the Holy Quran and the Bible mention the use of these plants as important culinary ingredients and valuable medicinal plants, further highlighting their historical and cultural significance (Block, 2001).

Onion and garlic are believed to have been introduced into the Central Asian regions, which are predominantly high-altitude areas, including Pakistan, Iran, Afghanistan, and several other countries of Central Asia (Brewster, 2008). Onions are rich in sulfur compounds, and the formation of propanethial-S-oxide through enzymatic activity is responsible for the tearing effect, while alkyl thiosulfates impart the characteristic aroma of *Allium* species. Due to their diverse range of phytochemicals, onions play an important role in health maintenance by offering protection against a wide spectrum of diseases. Organosulfur compounds present in onions exhibit antiallergic, antibiotic, and anti-inflammatory properties (Block *et al.*, 1997). In addition, onions contribute to cardiovascular and neurological health and possess antiviral and anticarcinogenic effects.

Onions also contain essential vitamins, such as vitamins A and C, along with various minerals, and exhibit strong antioxidant activity owing to their secondary metabolites (Nuutila *et al.*, 2003). Under conventional cultivation practices, onions are usually planted at a spacing of 10 cm between plants and 25 cm between rows (Khan, 2001). The performance of onion cultivars varies widely under different agro-climatic conditions, as interactions between environmental factors and genetic makeup significantly influence growth, yield, and quality. Consequently, no single cultivar performs uniformly across all environments, leading to variation in production and bulb quality. Previous studies have shown differential varietal responses under Pakistani conditions (Pakyurek *et al.*, 1994). Several onion cultivars are cultivated in Pakistan, including Tank Local, Peshawar Local, Dark Red, Bannu Local, Nasik Red, Shah Alam Local, Red Ball, Naurang Local, Panyala, Bhara Local, and Swat-1 (Jilani and Ghafoor, 2000).

Despite its importance, onion production in Pakistan remains low compared with other major onion-producing countries. Nutritional requirements, cultural practices, irrigation management, and plant protection measures are among the major factors influencing onion yield, in addition to favorable climatic conditions. In efforts to achieve higher yields and improved bulb quality, extensive research has been conducted under diverse agro-climatic conditions, with particular emphasis on the application of nitrogen, phosphorus, and potassium (NPK) fertilizers.

Potassium is an essential macronutrient required for optimal plant growth and development. It plays a key role in regulating transpiration, stomatal opening and closing, and maintaining water and tissue balance. Potassium also enhances crop quality attributes, including bulb size, sugar translocation, and carbohydrate production. In addition, it improves plant resistance to frost, drought, pests, and pathogens (Marschner, 1995). According to McCauley *et al.* (2017), factors influencing potassium availability in the soil solution include soil texture, pH, structure, aeration, and temperature. Despite these influences, potassium supply in the soil is often inadequate during critical growth and developmental stages of plants. Such deficiency restricts essential physiological processes, including photosynthate transport, protein synthesis, enzyme activity, and cell expansion, all of which are necessary for achieving high bulb quality and yield in onion (Williams and Kafkafi, 1998). Adequate and balanced nutrient supply is therefore a key determinant of high crop productivity (Lal *et al.*, 2002).

Numerous studies have highlighted the importance of potassium in enhancing onion growth and productivity. Potassium application significantly improves growth parameters such as plant height, number of leaves per plant, fresh and dry biomass, and total yield, along with other yield-related attributes (Abd El-Ah *et al.*, 2005). Adequate potassium availability in the soil is also associated with increased total soluble solids (TSS) and overall improvement in bulb quality (Geetha *et al.*, 1999).

Conversely, potassium deficiency reduces leaf area and dry matter accumulation, impairs bulb formation, and causes browning at the tips of older onion leaves (Wakeel and Mangan, 2017). The excessive use of chemical fertilizers has led to soil contamination with heavy metals, posing serious environmental and public health concerns. Such fertilizers deteriorate water quality, exceed natural soil buffering capacity, and may adversely affect human health and ecosystems (Gimeno-García *et al.*, 1996).

Commercial fertilizers contribute to the accumulation of trace and heavy metals in soils, thereby increasing the risk of exposure of crops, animals, and humans to toxic elements (Benson *et al.*, 2014). Potassium (potash), although a vital component of NPK nutrition, is often underutilized by growers, despite onion being a crop with high potassium demand (Nabi *et al.*, 2010).

Potash application is essential for achieving increased crop yields; however, the continuous use of chemical fertilizers is associated with environmental degradation and health risks. Moreover, losses through leaching and volatilization necessitate frequent fertilizer replenishment, while rising fertilizer costs limit farmers' ability to apply recommended rates. In contrast, organic fertilizers have demonstrated positive effects on plant growth and yield parameters in onion. These benefits are attributed to the role of potassium in promoting root growth, regulating enzymatic and hormonal activity, enhancing carbohydrate assimilation, improving water regulation, and facilitating the translocation of photosynthates from leaves to bulbs, ultimately increasing onion productivity (Diacono and Montemurro, 2011).

Organic fertilizers also enhance nutrient uptake by improving soil structure, regulating mineral and water movement, maintaining stomatal function, and increasing photosynthate accumulation (Geetha *et al.*, 1999). Balanced fertilizer use is well known to improve onion bulb quality. Among the various potassium sources available, organic potash (NKS) represents an important organic fertilizer. Its gradual nutrient release, sustained availability throughout the growing season, and environmentally friendly nature make it particularly effective for achieving higher and more sustainable onion yields. Based on the above-mentioned facts, the present study was carried out to determine the best level of organic potash to increase the production of different onions varieties under environment conditions of Peshawar.

MATERIALS AND METHODS

The study was conducted between January and May 2018 at The Agriculture University, Peshawar. A split-plot randomized Complete Block Design was used, including two variables in the research. It was designed to have three replications of each potash level that were placed in the main plots whereas different onion cultivars were placed in the sub-plots. The transplantation of seedlings is done on 15-January-2018 with plant spacing of 10 cm and row spacing of 20 cm.

Organic Potash Source

The organic potash used in this study was obtained from BSCR Organic Compost, Peshawar, which is a locally available farmyard manure (FYM)-based potassium source. This compost is rich in potassium along with essential macro- and micronutrients, making it suitable for sustainable crop production. The organic potash was applied in bagged form at the designated treatment levels (0, 80, 100, and 120 kg ha^{-1}) and thoroughly incorporated into the soil before planting. The use of organic potash not only provides a slow-release source of potassium but also improves soil organic matter content, water retention, and microbial activity, contributing to enhanced growth and yield of onion cultivars under field conditions.

Organic potash was applied through NKS (Nitrogen, Potassium and Sulphur) and applied as a soil-based fertilizer. Previous to application, the required quantity of NKS was calculated on a plot basis to ensure that the crop received the recommended potassium rate, considering its nutrient composition (4% Nitrogen, 30% Potassium, and 1% Sulphur). The NKS (Nitrogen, Potash, and Sulphur) used in our study was procured from Fauji Fertilizer Company (FFC), Pakistan. The fertilizer was uniformly broadcast by hand over the designated plots to achieve even distribution.

Factor A: Main Plot (levels of potash kg ha^{-1})

L_1 = Control

L_2 = 80

L_3 = 100

L_4 = 120

Factor B: Sub-plot (Onion cultivars)

V_1 = Swat-1

V_2 = Bhara local

V_3 = Nasik red (Indian)

Soil Characteristics

The collection and analysis of soil samples were done at the laboratory of the Soil and Environmental Sciences Department, The University of Agriculture Peshawar before the commencement of the planting. The analysis was done on a number of physical and chemical attributes of soil, and the results showed that Nitrogen (N) was 0.185 mg/kg, Phosphorus (P) was 6.12 mg/kg, Potassium (K) was 63.4 mg/kg, Organic Matter was 0.73 percent, pH was 7.3 and the Electrical Conductivity (EC) was 0.81.

Plant parameters

Plant Height (cm): The height of the plants was measured using a tape between the tip and the end of the plant and the values were recorded. A sample of five random plants of onion was taken where measurements were made.

Number of Leaves per Plant: The count of all the leaves in each plant was used by counting five leaves per plant in each of the replications of each treatment. The mean frequency of the plants with leaves was then determined.

Leaf Area (cm^2): The leaf area of five plants per treatment in each replication was measured using a leaf area meter and the average of the measures was calculated.

Bulb Diameter (cm): The diameter of the bulbs of five plants of each treatment were measured with a Vernier and the mean bulb diameter calculated.

Bulb Weight (g): The weight of the blubs of the five plants in each treatment were measured by a digital weighing balance and the average weight of the bulbs was calculated.

Neck Diameter (cm): The neck diameter of five casually chosen plants were measured using a Vernier caliper and the means were calculated by obtaining average.

Bulb Yield (t ha^{-1}): Bulb yields had been calculated using the weight of onions of each treatment and dividing it by the following formula.

Yield (t ha^{-1}) = (Weight in kg of onions per plot in m^2 x 1000)/ (Plot area m^2 x 1000).

Bulb Firmness (kg cm^{-2}): In order to determine bulb-firmness, a penetrometer was used. Firmness measurements of five randomly selected bulbs were made separately in each of the treatments. These individual measurements were the basis of the average firmness.

8. TSS (˚Brix): To determine the Total Soluble Solids (TSS), samples of onion of each treatment were ground. The liquid extract was put on a clean prism of a refractometer. The eyepiece was then focused on looking with the best ambient light on the sample with a lid. The TSS was recorded at the point of the mix of the white and blue colours (Manickavasagan *et al.*, 2014). This experiment was carried out on five randomly selected bulbs to be able to guarantee the reliability of the results.

Statistical Analysis

The data obtained from different parameters were analyzed using randomized complete block design (RCBD) with split plot scheme. Least Significant Difference (LSD) tests were used to perform mean comparisons. To conduct the statistical analysis of the data that was recorded, The Statistix software, version 8.1, was used, and the probability level was set at 1% and 5% (Jan *et al.*, 2009).

RESULTS AND DISCUSSION

The present research was carried out from January to May 2018 at The Agriculture University, Peshawar. The results of this study are presented in the following.

Plant Height (cm)

The analysis highlights that the onion plant height was significantly influenced by the choice of onion cultivars and the application levels of organic potash as shown in Table 1 and 2 and LSD values at $P \leq 0.05$ mentioned in Table 3. However, there was no significant interaction observed between the onion cultivars and the levels of organic potash. The results showed in Table 1 and Table 2, that the Swat-1 cultivar achieved the highest plant height at 71.57 cm, while the Bara local cultivar reached a height of 59.86 cm. The plant height of the Nasik Red cultivar was recorded as the shortest at 49.73 cm. On the other hand, results show that the tallest plants, measuring 63.92 cm, were found in plots with 120 kg ha^{-1} of organic potash, a height comparable to that of the control plots receiving 100 kg ha^{-1} of inorganic potassium and those applied with 100 kg ha^{-1} of organic potash. A plant height of 55.70 cm, the lowest among treatments, was observed in the 80 kg ha^{-1} organic potash plots.

These differences in height among the cultivars were influenced by their genetic makeup and their adaptability to the specific environmental conditions (Khan *et al.*, 2001). Additionally, Faisalabad and Swat-1 cultivars were reported to produce the tallest plants. The dose of organic potash at 100 and 120 kg ha^{-1} led to the highest plants, likely due to the slow-release nature of organic potash, which provides a steady supply of nutrients over an extended period (Diacono and Montemurro, 2011). Nabi *et al.*, (2010) found that the tallest onion plants were obtained with potash applications of 100 and 75 kg ha^{-1}. Similarly, Hassanpouraghdam *et al.* (2008) observed significant effects of various concentrations of potash and nitrogen on plant height. Organic fertilizers are known to promote growth by supplying nutrients at a gradual rate and over a longer duration (Funda, 2011).

Number of Leaves Plant^{-1}

The analysis of variance indicates that the leaves plant^{-1} are significantly influenced by both the onion cultivars and the levels of organic potash at P≤0.05 (Table 1-3). However, there was no significant interaction between the levels of organic potash and the onion cultivars. Among the different cultivars, cv. Swat-1 exhibited the highest number of leaves per plant (11.57), followed by cv. Bara Local, whereas cv. Nasik Red had the lowest number of leaves per plant (8.25) (Table-1, and LSD values at P ≤ 0.05 mention in Table-3). The Table 2 application of 100 kg ha^{-1} of control plot produced the highest leaf count per plant (11.77), a result statistically similar to the leaf count (11.33) achieved at 120 kg/ha of organic potash. In contrast 80 kg/ha of organic potash showed in the lowest leaf count per-plant (7.55). The superior performance of cv. Swat-1 in terms of leaf production could be attributed to its genetic characteristics and its flexibility to the soil and climatic conditions, which influence nutrient utilization efficiency and overall growth [9] (Pakyurek *et al.*, 1994). Potash is crucial for enhancing vegetative traits, including the number of leaves (Prajapati and Modi, 2012). Organic potash provides prolonged availability of potassium due to its slow-release nature, which contributes to an increased leaf count (Diacono and Montemurro, 2011). Potassium is essential for photosynthesis and has a significant impact on plant growth (El-Nagger and El-Nasherty, 2016). Baloch *et al.* (1991) found that applying 100 kg ha^{-1} of potassium yielded the highest number of leaves per plant. In contrast, a shortage of potassium can cause a decrease in both leaf size and quantity (Pettigrew, 2008).

Leaf Area Plant^{-1} (cm^2)

According to the data summarized in Table 1, Table 2, and LSD values at P ≤ 0.05 mentioned in Table 3, the leaf area measurements were significantly influenced by both the onion cultivars and the levels of organic potash. However, the interaction effect between the cultivars and potash levels was not significant. Table 1 indicates that cv. Swat-1 demonstrated the largest leaf area per plant at 1206.7 cm², which was statistically similar to cv. Bara Local's 1133.4 cm². In comparison, cv. Nasik Red showed the smallest leaf area per plant, measuring 801.1 cm².In a similar plants or veins that obtained 100 kg ha^{-1} of inorganic potassium had the largest leaf area (1246.7 cm²), which was comparable to the leaf area of plants treated with 120 kg ha^{-1} of organic potash (1192.4 cm²). while the lowest level of organic potash (80 kg ha-1) showed the smallest leaf area per plant (751.0 cm2). Reasonably, the cultivars Swat-1 and Bara Local demonstrated a greater leaf area per plant than Nasik Red.

These variations among cultivars may be attributed to their adaptability to the environmental conditions of the area (Reshma *et al.*, 2017). The significant impact of organic potash on leaf area can be linked to potassium's role in regulating stomatal activity for photosynthesis and controlling various biological and enzymatic processes. Organic fertilizers may exert their effects through a continuous supply of potassium (organic potash), which facilitates cell growth and division, enhancing vegetative features and increasing leaf area (Sober *et al.*, 1981). In addition, Tolan and Zeevaart (1992) found that these fertilizers promote vegetative growth, with higher potash levels resulting in a corresponding enhancement of the leaf-area (Asif *et al.*, 2007).

Bulb Diameter (cm)

Tables 1 to Table 3 give the results regarding bulb-diameter and the analysis of the data demonstrated that the effect of both cultivars and the concentrations of organic potash were found to have a significant impact on the bulb diameter of onions. However, the cultivar and the levels of organic potash did not interact significantly. Among the onion cultivars, Swat-1 had the highest bulb diameter with an average of 6.66 cm. This was followed by Bara Local Cultivar which had an average diameter of 5.88 cm. Conversely, the least bulb diameter was found in the Nasik Red cultivar which had an average of 4.67cm in terms of bulb diameter, with the ultimate average of 6.47 cm of the same being recorded in an application of 120 kg ha^{-1}. The 100 kg ha^{-1} organic potash treatment had a bulb diameter of 6.17 cm, which is statistically equal to that produced, and the minimal diameter of 5.1 cm was obtained with 80 kg ha^{-1}. Swat-1 remained the largest bulb manufacturer.

This may be explained by the fact that it had a larger leaf area and number of leaves which would have contributed to higher photosynthesis and hence a larger bulb diameter. It is possible that the high performance of Swat-1 over other cultivars could be associated with its genetic composition and a good adaptation to the soil and the environment of the experimental location (Akhtar *et al.*, 2002). The most significant bulb diameters were obtained with the application of Organic potash in doses of 120 and 100 kg ha^{-1}. This is probably because organic potash is a good source of potassium which is not released at a very high rate resulting in sufficient supply of potassium to the plants. Organic fertilizers are also important in enhancing microbial activity and refurbishing the nutrient cycle in the soil, which improves the availability of nutrients to plant growth (Funda *et al.*, 2011). Potassium controls the water balance by stomatal conductance, plays a crucial role in absorption of other nutrients, which plays a major role in the overall enlarging of the bulb size.

Table 1. Performance of onion cultivars for different parameters.

Parameter	Swat-1	Bara Local	Nasik Red	Mean
Plant Height (cm)	71.57 A	59.86 B	49.73 C	60.72
Number of Leaves	11.75 A	10.58 B	8.25 C	10.19
Leaf Area (cm²)	1206.7 A	1133.4 A	801.1 B	1047.8
Bulb Diameter (cm)	6.66 A	5.88 B	4.76 C	5.76
Bulb Weight (g)	147.76 A	105.32 B	56.98 C	103.02
Neck Diameter (cm)	0.89 A	0.82 A	0.58 B	0.76
Bulb Yield (tons/ha)	23.05 A	17.92 B	13.50 C	18.82
Firmness (kg/cm²)	5.75 B	6.67 A	5.20 C	5.87
TSS (°Brix)	12.01 A	11.60 A	9.59 B	11.07

Table 2. Effect of organic potash levels for different morpho-physiological and yield parameters.

Organic Potash Levels (Kg ha^{-1})	Plant Height (cm)	Number of Leaves	Leaf Area (cm²)	Bulb Diameter (cm)	Bulb Weight (g)	Neck Diameter (cm)	Bulb Yield (tons/ha)	Firmness (kg/cm²)	TSS (°Brix)
Control	61.97 A	11.77 A	1247 A	5.10 B	89.53 B	0.79 A	15.96 A	5.83 AB	10.18 C
80 kg/ha	55.70 B	7.55 C	751.0 C	5.34 B	84.44 B	0.56 B	12.86 C	5.16 B	8.90 D
100 kg/ha	59.96 AB	10.11 B	998.0 B	6.17 A	110 AB	0.84 A	20.30 A	6.20 A	11.92 B
120 kg/ha	63.92 A	11.33 AB	1192 A	6.47 A	129.5 A	0.87 A	23.46 A	6.30 A	13.27 A
Mean	60.72	10.19	1047.8	5.76	103.02	0.76	18.82	5.87	11.07

Table 3. LSD Values for Onion Cultivars' Performance Across Different Parameters:

Parameter	LSD for (Cultivars)	LSD for (Organic Potash Levels)
Plant Height (cm)	5.4	4.6
Number of Leaves	0.6	1.4
Leaf Area (cm²)	74.65	165.65
Bulb Diameter (cm)	0.42	0.68
Bulb Weight (g)	22.93	31.39
Neck Diameter (cm)	0.13	0.1
Bulb Yield (t ha^{-1})	4.44	3
Firmness (kg cm^{-2})	0.41	0.79
TSS (°Brix)	0.69	1.19

Bulb Weight (g)

It was found that the onion cultivar, as well as the levels of organic potash, had a large impact on the weight of the bulb, but the interaction between the two was not significant (Table 1, Table 2). As far as the data shows, Swat-1 cultivar had the largest bulb weight that was 147.7 g, and Bara Local came after it, 105.3 g. Conversely, the least weight of the bulb was documented in the cultivar Nasik Red and this was 56.98 g. Concerning the influence of the level of organic potash on the weight of bulbs as described in Table 2, plants receiving organic potassium 120 kg ha-1 recorded the highest weight of 129.47 g, which had no statistical difference with the weight in plants that received potassium 100 kg ha-1. On the other hand, plants that had the least weight of bulb at 84.44 g were those that had potash 80 kg ha-1. The cultivar had a great influence on the bulb weight, but Swat-1 was superior to the other cultivar, having better leaf count, and area, and better height of the plant, resulting in better growth and better bulb weight. Increased photosynthesis resulting in improved growth in vegetation due to increased growth leads to increased weight of the bulb (Sultana *et al.*, 2005). The authors postulate that genetic and cultivar qualities may be one of the factors behind the improvements in the weight and production of the bulbs (Khan *et al.* 2001). The beneficial effect of organic potash on the weight of the bulb can be attributed to its effects on the improvement of soil chemical and physical composition that facilitates long-term provision of nutrients (Kaur, 2005). Organic fertilizers increase nutrient availability and source-sink association, which result in the increase of photosynthates in storage organ (Kashyap, 2010). Potassium also helps to amplify the water retention in plant organs under the earth, and this enhances the production of the onions (Mahadik and Chopde, 2015). Potash 100 and 120 kg/ha gave the highest weights of the bulbs. Moreover, the number of leaves and the size of the leaf also had a positive effect on the bulb weight (Ashrafuzzaman *et al.*, 2009). Potassium is also important in the determination of the quality and weight of the bulbs (El-Desuki *et al.*, 2006).

Neck Diameter (cm)

The results displayed in Table-1 to Table-3 show neck diameters of onions for different cultivars and potash application. The use of organic potash and various cultivars affected the neck diameter of onions significantly as compared to the interactions between the level of organic potash and the cultivars. The results of the information on the different onion cultivars showed that the highest neck diameter was recorded at 0.89 cm and it was statistically comparable to the neck diameter of the cv. Bara Local (0.82 cm) though the cv. Nasik red had the lowest neck diameter at 0.58 cm. The onions grown using 120 kg ha-1 of organic potash had the largest neck diameter 0.87 cm which was significantly associated with the neck-diameter measured potash using 100 kg ha^{-1} (according to the mean data of the different levels of potash). On the other hand, the minimum neck-diameter was 0.56 cm and had 80 kg ha^{-1} potash. These variations in the diameter of the neck between different cultivars can be explained by the adaptability of the cultivar to particular agro-climatic conditions or their genetic makeup. The highest value of neck-diameter was observed at plots that had been treated with 100 and 120 kg ha^{-1} organic potash. Potash is essential in the regulation of stomatal activity and in photosynthetic products production, and their accumulation. It is possible to explain this increase in the diameter of the neck by the fact that photosynthates produced by the leaves and accumulated in the bulbs are improved and this results in the increase of the bulb size and weight (Shaud *et al.*, 2013). Kumar *et al.* (2011) also noted the same effects in onions in response to the application of different levels of potash.

Bulb Yield (t ha^{-1})

The mean yield of bulbs was significantly/ affected by the differences in the organic potash, and the onion cultivars were significantly affected (LSD values at P ≤ 0.05 mentioned in Table 3). Although these are major effects, the relationship between the levels of organic potash and the cultivars were not significant. Table 1 and Table 2 showed that Swat-1 cultivar produced the highest yield of 23.05 t ha-1 of the bulb, followed by the Bara local cultivar with a yield of 17.92 t ha^{-1}. On the contrary, the Nasik red cultivar brought the lowest yield of bulbs of 13.5 t ha-1. Figure 4.2 the impact of organic potash, the plots that received the largest application of 120 kg ha^{-1} gave the highest yield of the bulbs at 23.46 t ha-1. This production was statistically equal to potash 100 kg ha-1 treated plants. On the other hand, the lowest income was 12.86 t ha^{-1} with designs that had potash 80 kg ha^{-1}. Although there are several cultivars, Swat-1 cultivar had the highest yield, and this could be attributed to its genetic makeup and adaptation to the prevailing agro-climatic conditions. During the growing season, the accessibility and length of supply of potash as an organic source had a positive influence on the growth parameters that elicited a significant yield of onions. Potash plays a major role as a hormone in stimulating the growth of the roots, balancing enzyme and hormone activities, promoting the production and transportation of carbohydrates to the bulbs, controlling the osmotic movement of water and stomatal transpiration, and enhancing the distribution of assimilates to the leaves (Sharma *et al.*, 2003; Girigowda *et al.*, 2005).

Bulb Firmness (kg cm^{-2})

Table 1 and Table 2 are data on the firmness of the bulbs that are presented. It can be seen that the analysis revealed that firmness of onion bulbs was highly affected by dissimilar potash content and by different cultivars. The cultivars showed the greatest bulb firmness of 6.67 kg cm 2 with Bara local, and 5.57 kg cm^2 with Swat-1 with the lowest being 5.20 kg cm 2 with Nasik red. As far as the potassium contents are concerned, organic potassium at 120 kg ha^{-1} recorded the most intense blub firmness of 6.3 kg cm2, which was equal to that at potash 100 kg ha^{-1}. The lowest bulb firmness was recorded in plants that were treated with 80 kg ha^{-1} organic-potash. Bara local cultivar was found to have better firmness of the bulb than swat-1 and Nasi red. This attribute is essential because the greater the firmness, the longer shelf life, and therefore, such types are good to store and market. Bulb firmness was the greatest with the use of organic potash at 120 and 100 kg ha^{-1}. Demiral and Koseoglu (2005) found that the degree of bulb firmness increased with the use of potash and Asri and Sonmez (2010) added that there was a significant increase in the degree of bulb firmness with the use of potash at 100 Kg ha^{-1}.

Total Soluble Solids (TSS °Brix)

The results given in Table 1 and Table 2 show the information on Total Soluble Solids (TSS) of the various cultivars of onions in relation to the concentration of organic potash (LSD values at P ≤ 0.05 mention in Table 3). Statistically valuations showed that the type of potash organics content of the onions and the type of onion cultivar had an important influence on the TSS content of the onions. Nevertheless, the relation between organic potassium and cultivars was not significant. Out of the different onion cultivars Table 1 and Table 2, the cultivar Swat-1 had the highest TSS of 12.01 -1 Brix, which was statistically equal to the cultivar Bara Local with 11.6 -1 Brix. On the other hand, the TSS of the Nasik Red cultivar was the lowest at 9.59 o Brix. Based on the average values of TSS, the maximum value of 13.27 o Brix was recorded in plants treated with potash 120 kg ha^{-1}. Relative to this, the plants which were treated with potash 100 kg ha-1 had lower TSS and the lowest TSS was observed to be 8.9 o Brix in those plants which were treated with potash 80 kg ha^{-1}. It shows how potash is critical in meeting the nutrient demands of bulbous plants such as onions which are high in nutrients. As organic potash is a slow-release fertilizer, it provides the nutrients within a long time, thus leading to elevated photosynthetic accumulation and activation of different enzymes, and this may raise the content of TSS. The increased concentration of potassium greatly enhanced the TSS of onions, the increased carbohydrate synthesis of Photosynthesis, and the improved transportation of Photosynthates between the leaves and the bulbs, which is probably responsible. Nabi *et al.* (2010) found that onion. A maximum of 100 kg ha^{-1} of potash caused maximum soluble solids (TSS) using onion bulbs. This observation is consistent with the results of other studies that show the involvement of Potash in the enhancement of the TSS content in onions (Pramanick *et al.*, 1999; Yadav *et al.*, 2002; Hariyappa, 2003).

CONCLUSIONS AND RECOMMENDATIONS

Among various onion cultivars, the Swat-1 variety exhibited the highest measurements in Plant height, leaf Count, Leaf Area, bulb Weight, Bulb Diameter, Neck Diameter, bulb Yield, and Total Soluble Solid (TSS) content. The Bara Local cultivar demonstrated comparable results in leaf Area, Neck Diameter and Total Soluble Solid (TSS) content to 'SWAT-1' while also showing superior Bulb Firmness compared to Nasik Red. Applying organic potash at a rate of 120 kg/ha yielded the highest height, bulb weight, bulb diameter, neck diameter, bulb yield, blub firmness, and TSS content. However, the effect of 120 kg/ha of organic potash was statistically similar to those observed with 100 kg/ha of organic potash. The findings suggest that applying organic potash at 100 kg ha^{-1} ensures optimal onion production, while the cultivar Swat-1 is best suited for cultivation under the agro-climatic conditions of Peshawar.

AUTHOR CONTRIBUTIONS

Sadeeq Akbar: Writing – original draft. Babar Ali: Writing, Supervision, reviewing, and editing. Muhammad Rizwan: Writing, data handling, and statistical analysis. Imran Ullah: Experimental work and data collection. Muhammad Masoom: Data analysis and interpretation. Zubair Ahmed Pirzada: Investigation and reviewing. Muhammad Sulaiman: Writing – review & editing. Masood Ahmad: Proof reading and reviewing. Ahmad Sher: Statistical analysis and reviewing.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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