***Original Research Article***

**The response of selected potato varieties to different levels of vermicompost in Bangaladesh**

**Abstract**

This study investigates the impact of five levels of vermicompost application on the yield and quality of various potato varieties at Sher-e-Bangla Agricultural University in Bangladesh. The experiment was conducted following a two-factor split-plot design with three replications and four potato varieties (BARI Alu-68, BARI Alu-29, BARI Alu-25, and BARI Alu-28) along with five levels of vermicomposting (0, 3, 6, 9, and 12 t ha⁻¹). The important agronomic parameters (i.e. the number of tubers per hill, average tuber weight, and overall tuber yield) were significantly affected due to both variety and level of vermicompost.BARI Alu-25 (Asterix) emerged as the superior variety, exhibiting the highest average tuber weight (49.07 g), tuber yield (28.38 t ha⁻¹), and starch content (22.72 mg g⁻¹ FW). Higher vermicompost applications (9 and 12 t ha⁻¹) generally resulted in improved yield and quality metrics, such as increased tuber weight and marketable yield. Additionally, vermicompost positively influenced processing qualities like dry matter content, total soluble solids, and starch content, which are crucial for potato processing. Strong correlation (r= .., P< …. ) between various yield and quality parameters highlighting the potential of vermicompost as a sustainable soil amendment. The findings suggest that optimizing vermicompost use can enhance potato production and quality, offering economic benefits to farmers and contributing to sustainable agricultural practices in Bangladesh. Further research is recommended to explore the long-term effects and interactions with other agronomic practices.

**Keywords:** Influence, Potato, Processing, Vermicompost, Yield

**1.Introduction**

The cultivation of potatoes (*Solanum tuberosum* L.) is of significant importance in global agriculture, serving as a staple food crop and a vital source of nutrition for millions of people worldwide (Devaux *et al*., 2021; Campos and Ortiz, 2019; Birch *et al*., 2012; Devaux *et al*., 2020; Johnson and Cheein, 2023; Manogna, 2021). Potatoes are rich in carbohydrates, vitamins, and minerals, making them an essential component of diets in many countries (Alam and Baset, 2009; Zaheer and Akhtar, 2016; Camire *et al*., 2009; Robertson *et al*., 2018). In Bangladesh, potato production plays a crucial role in food security and the national economy. The potato industry in Bangladesh has experienced substantial growth over the years, driven by increasing demand and the need for sustainable agricultural practices (Roy *et al*., 2017; Hossain, 2016).

Vermicomposting, the process of using earthworms to convert organic waste into nutrient-rich compost, has emerged as a promising technique for enhancing soil fertility and crop productivity (Doan *et al*., 201; Manivannan *et al*., 2009). Vermicompost is known for its ability to improve soil structure, increase water retention, and provide essential nutrients to plants ( Ceritoğlu et al., 2018; Tammam et al.,2022). Its application in agriculture has been shown to enhance crop yields and quality, making it an attractive option for sustainable farming practices (Gazi *et al*., 2004; Lim *et al*., 2015; Rahman *et al*., 2023).

This study aims to investigate the impact of vermicompost application on the yield and processing quality of different potato varieties in Bangladesh. By examining the effects of varying levels of vermicompost on key agronomic and quality parameters, this research seeks to provide insights into the potential benefits of vermicompost as a soil amendment for potato cultivation. The findings of this study can inform agricultural practices and contribute to the development of sustainable potato production systems in Bangladesh.

In the context of potato cultivation, several studies have demonstrated the beneficial effects of vermicompost. For instance, Rahmawati *et al*., (2022) observed that the application of vermicompost increased tuber weight and overall yield of potato?. Porter *et al*., (1999) reported that organic fertilizer management, including vermicompost, resulted in higher tuber yields and improved soil conditions. Further, researchers have also reported positive impact of vermicompost on potato growth and development in Bangladesh (Yadava *et al*., 2024; Mostofa *et al*. 2021)

The processing quality of potatoes is another critical aspect influenced by vermicompost application. High dry matter content, specific gravity, and starch content are desirable traits for processing potatoes. Studies have shown that vermicompost can enhance these qualities, making potatoes more suitable for processing into various products (Badrunnesa *et al*.,2021; Ferdous *et al*., 2019).

This study aims to contribute to the understanding of the potential benefits of vermicompost application in potato cultivation. By providing insights into the effects of vermicompost on yield and processing quality, this research can help farmers and agricultural practitioners to optimize their practices for sustainable potato production in Bangladesh. The findings of this study have the potential to enhance food security and economic returns for potato farmers in Bangladesh.

**2.Materials and Methods**

**2.1 Experimental Site and Climate**

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The site is located at 23° 7′ N latitude and 93° E longitude, with an altitude of 8.6 meters above sea level. The experimental area belongs to the agro-ecological zone of "Madhupur Tract," AEZ-28. The climate is characterized by a winter with a significant monsoon, typical of a sub-tropical cropping zone during the months from November 2016 to April 2017 (Rabi season). The soil is silty clay with slight sandy loam texture, and the topography is medium flat with easy irrigation and drainage systems.

**2.2 Planting Materials**

Potato (*Solanum tuberosum L.*) was used as the test crop. The varieties used in the experiment were collected from the Tuber Crops Research Centre (TCRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur; Bangladesh Agricultural Development Corporation (BADC), Domar farm, Nilphamari; and BARI, Debigonj farm, Panchagarh. The selected varieties for the experiment were BARI Alu-68 (Atlantic), BARI Alu-29 (Courage), BARI Alu-25 (Asterix), and BARI Alu-28 (Lady rosetta). These varieties were chosen to assess their processing quality and to standardize a sustainable production package through vermicompost application adjusted with harvesting time, aiming to improve the income status of potato farmers in Bangladesh.

**2.3 Experimental Design**

The experiment was laid out in a two-factor split-plot design with three replications. The main plots were assigned to the varieties, and the sub-plots were assigned to the vermicompost levels. The total number of unit plots was 60, with each plot measuring 2.5 m × 2.5 m.

**2.4 Experimental Treatments**

The experiment comprised two factors:

**2.4.1 Factor A: Variety**

V₁ = BARI Alu-68 (Atlantic)

V₂ = BARI Alu-29 (Courage)

V₃ = BARI Alu-25 (Asterix)

V₄ = BARI Alu-28 (Lady rosetta)

**2.4.2 Factor B: Vermicompost Level**

Vm₁ = 0 t ha⁻¹

Vm₂ = 3 t ha⁻¹

Vm₃ = 6 t ha⁻¹

Vm₄ = 9 t ha⁻¹

Vm₅ = 12 t ha⁻¹

**2.5 Seed Preparation**

Tubers of uniform size (50-60 g) were used for planting. The tubers were kept at room temperature to facilitate good sprouting. Fully sprouted potato tubers were used as planting material.

**2.6 Land Preparation**

The land was prepared in the second week of November using a power tiller. The land was ploughed and cross-ploughed four times, followed by laddering. Weeds and stubbles were removed, and drainage channels were made to avoid waterlogging. The soil was treated with Furadan 5G @ 20 kg ha⁻¹ to protect young plants from cutworms.

**2.7 Fertilizer and Manure Application**

The crop was fertilized using the recommended dose of fertilizers: 350 kg ha⁻¹ of Urea, 220 kg ha⁻¹ of TSP, 250 kg ha⁻¹ of MoP, 120 kg ha⁻¹ of Gypsum, and 10 kg ha⁻¹ of Zinc sulphate. Vermicompost was applied as per the treatment. Zinc sulphate and vermicompost were applied during the last ploughing. Half of the urea, along with full doses of TSP, MoP, and gypsum, was applied in furrows during tuber planting. The remaining urea was applied at 35 days after planting (DAP) as top dressing.

**2.8 Planting of Seed Tuber**

Well-sprouted, healthy, and uniform-sized potato tubers were planted at a depth of 5-6 cm on November 15, with a spacing of 50 cm × 25 cm.

**2.9 Intercultural Operations**

**2.9.1 Earthing Up:** Earthing up was done at 35 DAP and 50 DAP to reduce solonization of potato tubers and to facilitate tuber development.

**2.9.2 Weed Removal:** Weeding was done two weeks after emergence and before the second top dressing of urea. Additional weeding was done as needed to keep the crop free from weeds.

**2.9.3 Watering and Drainage:** Three irrigations were provided at 35, 50, and 65 DAP. Top dressing of urea was followed by irrigation for proper utilization of fertilizers.

**2.9.4 Control of Insects and Diseases:** Dursban @ 7.5 liters ha⁻¹ was drenched at 30 DAP to control cutworms. Dimecron 100 EC @ 2% and Admire 200 SL @ 0.5% were applied to control aphids and jassids. Dithane M-45 @ 2 g liters⁻¹ and Ridomil Gold MZ @ 1 g liters⁻¹ were applied to prevent late blight.

**2.9.5 Haulm Cutting**

Haulm cutting was done in the second week of March when 60-70% of the plants showed senescence. The potatoes were harvested after 7 days of haulm cutting for skin hardening and tuber bulking.

**2.10 Data Recording**

Data were collected on various parameters, including:

1. Number of tubers per hill
2. Weight of tubers per hill (g)
3. Average weight of tuber (g)
4. Tuber yield (t ha⁻¹)
5. Marketable yield (t ha⁻¹)
6. Non-marketable yield (t ha⁻¹)
7. Specific gravity (g cm⁻³)
8. Dry matter content (%)
9. Total soluble solid (°brix)
10. Starch content (mg g⁻¹ FW)
11. Reducing sugar (mg g⁻¹ FW)

**2.11 Procedure of Data Recording**

**2.11.1 Number of Tubers per Hill:** Five hills were selected from each plot. The entire tuber was counted from five hills, and then the mean values of tuber per hill were calculated.

**2.11.2 Weight of Tubers per Hill (g):** Five hills were selected from each plot. The entire tuber was weighed from five hills using an electronic balance, and then the mean values of tuber weight per hill were calculated in gram units.

**2.11.3 Average Weight of Tuber (g):** Five hills were selected from each plot. The entire tuber (>20 g) was counted and weighed from five hills using an electronic balance. To calculate the average tuber weight, the weight of the total tuber per hill was divided by the number of tubers per hill, and then means were taken in gram units.

**2.11.4 Tuber Yield (t ha⁻¹):** The entire tuber was weighed using an electronic balance from 1 m² harvested area of each plot. Then the weight of the tuber per meter square was converted to per plot and then again converted to t ha⁻¹.

**2.11.5 Marketable Yield (t ha⁻¹):** Tubers (>20 g) were considered marketable. The entire tuber was weighed using an electronic balance from 1 m² harvested area of each plot. Then the means were taken in ton per hectare units.

**2.11.6 Non-Marketable Yield (t ha⁻¹):** Tubers (<20 g) were considered non-marketable. The entire tuber was weighed using an electronic balance from 1 m² harvested area of each plot. Then the means were taken in ton per hectare units.

**2.11.7 Specific Gravity (g cm⁻³):** Specific gravity was measured using the following formula (Gould, 1995). Five tubers were taken from each plot after harvest of treatment, and then the means were taken.

$$Specicifc gravity (\frac{g}{cubic centimeter})=\frac{Weight of tuber in air}{Weight of equal volume of water at 4°C}$$

**2.11.8 Dry Matter Content (%):** The potato tuber samples were kept in separate envelopes for each plot, and five potato tubers were taken after harvest to calculate the DMC. They were oven-dried at 70°C for 72 hours. Dry weight was determined with a digital balance, and means were calculated in percent units.

 DMC= $\frac{Dry weight}{Fresh weight }×100$

**2.11.9 Total Soluble Solid (TSS) (°brix):** Total Soluble Solid (TSS) of harvested tubers was determined after harvest in a drop of potato juice using a Hand Sugar Refractometer "ERMA" Japan, Range: 0-32%, according to (AOAC, 1990) and recorded as °brix from direct reading of the instrument.

**2.11.10 Starch Content (mg g⁻¹ FW):** Starch content of tubers was determined after harvest by the Somogyi-Nelson method (Nelson, 1944). The residue remaining after extraction for sugar was washed several times with water to ensure no more soluble sugar in the residues. Starch content was calculated using the glucose standard curve.

**2.11.11 Reducing Sugar (mg g⁻¹ FW):** Reducing sugar was estimated by the photometric adaptation of the Somogyi method (Nelson, 1944) with some modifications. The residue used for sugar analysis was extracted from 1 g of fresh sample of chopped potato, smashed well in a motor, and extracted using 80% ethanol. The reducing sugar content was calculated using the glucose standard curve.

**2.12 Correlation Coefficient (r)**

Correlation coefficients between different yield and quality contributing traits were calculated using Microsoft Excel. The correlation coefficient (r) measures the strength and direction of a linear relationship between two variables. The correlation coefficients were calculated to understand the relationships between various parameters such as tuber yield, specific gravity, dry matter content, total soluble solids, starch content, and reducing sugar.

**2.13 Statistical Analysis**

Collected data on different parameters were analyzed statistically using the analysis of variance (ANOVA) technique with the help of WASP (Web Agri Stat Package: version-1) computer program. Means were adjusted using LSD (Least Significant Difference) at a 5% level of probability. Raw data management and graphical representation were done using Microsoft Excel. This comprehensive methodology ensures a thorough and systematic approach to investigating the influence of vermicompost on the yield and processing quality of selected potato varieties, along with the correlation between different yield and quality contributing traits.

**3. Results and Discussion**

**3.1 Number of tubers hill-1**

The number of tubers hill-1 was found significant (*P* ≤0.01) due to different potato varieties (Table-1). The maximum number (13.484) was found in case of V1 which was statistically similar to V2 (13.327) followed by V3 and minimum was in V4 (10.273). A significant (*P* ≤0.01) effect was found from vermicompost application on number of tubers hill-1 (Table-2). A decreasing trend was found with increasing of vermicompost in case of number of tubers hill-1. The maximum number (13.062) was found in Vm3 which was statistically similar to Vm1 and Vm2. The minimum number (10.944) was found in Vm4 which was statistically similar to Vm5. Combinedly, a significant (*P* ≤0.01) variation was found among the treatment against average weight of potato tubers (Table-3). Combinedly, the maximum number (14.113) was found in V1Vm1 which was statistically similar to maximum treatment combinations while the minimum number (7.877) was found in V3Vm4 which was statistically similar to V3Vm5, V4Vm4 and V4Vm5 (Table-3).

According to the available reports the increase of stem numbers is led to the increase of tubers and on the other hand the yield of Potato is related to the tubers and the average weight of them (Zeleke and Getahun,2024). Kumar and Singh, (2020) stated that the use of compost and vermicompost significantly led to the tuber increase and the number of main and sub stems.

**3.2 Average weight of tuber (g)**

Mean weight of tuberswas found significant (*P* ≤0.01) against different potato varieties (Table-1). The highest average weight (49.1 g) of tuber was found in V3 treatment which was statistically similar to V4 and the lowest (30.7 g) was recorded in V1. In respects of average weight of potato tubers, a remarkable variation (*P* ≤0.01) was noted (Table-2) against different levels of vermicompost application. Average weight of tuber increased with increasing of vermicompost level. The highest average weight (47.747 g) of tuber was found from Vm5 treatment which was statistically similar to Vm4 and the lowest (73 g) was in Vm1. Combinedly, a significant (*P* ≤0.01) variation was found among the treatment against average weight of potato tubers (Table-3). The highest average weight (60.247 g) of tuber was found from V3Vm4 treatment combination which was statistically similar to V3Vm5, V4Vm4 and V4Vm5. The lowest average (29.207 g) was in V1Vm1 treatment combination which was statistically similar to rest of the treatment combinations (Table-3). More absorption of soil nitrogen from vermicompost application induced more protein partitioning into the growing tubers may be the main reason for the highest average weight of tuber.

**3.3 Weight of tubers hill-1 (g)**

Weight of tuberswas found significant (*P* ≤0.01) against different potato varieties (Table-1). The highest weight (472.2 g) of tuber was found from V3 treatment which was statistically similar to V4 and the lowest (418.78 g) was in V1. In respects of weight of potato tubers, a remarkable (p≤0.01) variation was noted against different levels of vermicompost applications (Table-2). The highest weight (479.57 g) of tuber was found from Vm5 which was statistically similar to treatment Vm4 and the lowest weight (427.33 g) was in Vm1. Combinedly, a significant (*P* ≤0.01) variation was found among the treatment against weight of potato tubers (Table-3). The highest weight (544.49 g) of tuber was found from V4Vm5 treatment combination which was statistically similar to V4Vm4,V3Vm4 and V3Vm5. The lowest (408.12 g) was in V1Vm1 treatment combination. Higher average tuber weight hill-1 may be the reason for higher weight of tuber hill-1. Barman et al., (2018) mentioned that the application of NPK and vermicompost showed an increment in the average tuber weight per plant. Zakaria *et al*., (2022) also reported that maximum weight of tubers (39,717 g plant-1) was recorded when organic fertilizer managements were applied.

**3.4 Tuber Yield (t ha-1)**

Yield of tuberswas found significant (*P* ≤0.01) against different potato varieties (Table-1). The highest (28.79 t ha-1) tuber yield was found from V4 treatment which was statistically similar to V4 treatment and the lowest (24.63 t ha-1) was in V1. In respects of yield of potato tubersa remarkable (*P* ≤0.01) variation was noted against different levels of vermicompost applications (Table-2). The highest (30.97 t ha-1) tuber yield was found from Vm4 treatment which was statistically similar to Vm5 treatment and the lowest (25.25 t ha-1) was in Vm1. Combinedly, a significant (*P* ≤0.01) variation was found among the treatment against yield of potato tubers (Table-3). The highest tuber yield (33.56 t ha-1) was found from V2Vm4 treatment combination which was statistically similar to V3Vm4, V3Vm5, V4Vm4 and V4Vm5 while the lowest (24.38 t ha-1) was in V1Vm2. The highest weight of tuber hill-1 and highest average weight of tuber might be the main reason for highest tuber yield ha-1. The increase in average tuber weight of potato with the supply of fertilizer nutrients could be due to more luxuriant growth, more foliage and leaf area and highest supply of photosynthesis, which helped in producing bigger tubers, hence resulting in highest yields.

**3.5 Marketable yield (t ha-1)**

Marketable yield of tuberswas found significant (*P* ≤0.01) against different potato varieties (Table-1). The highest (26.64 t ha-1) yield was found from V3 treatment followed by V2 treatment and the lowest (21.88 t ha-1) was in V1. In respects of marketable yield of potato tubersa remarkable (*P* ≤0.01) variation was noted against different levels of vermicompost applications (Table-2). The highest yield (29.06 t ha-1) was found from Vm4 treatment which was statistically similar to Vm5 treatment and the lowest (22.59 t ha-1) was in Vm1. Combinedly, a significant (*P* ≤0.01) variation was found among the treatment against marketable yield of potato tubers (Table-3). The highest yield (31.34 t ha-1) was found from V4Vm5 treatment combination which was statistically similar to V4Vm4, V3Vm4, V3Vm5, V2Vm5 and V2Vm4 while the lowest (21.60 t ha-1) was in V1Vm2.

**3.6 Non-marketable yield (t ha-1)**

Non-marketable yield of tuberswas found significant (*P* ≤0.01) against different potato varieties (Table-1). The highest (2.75 t ha-1) yield was found from V1 treatment which was statistically similar to V2 and V4 and the lowest (1.75 t ha-1) was in V3. In respects of non-marketable yield of potato tubersa remarkable (*P* ≤0.01) variation was noted against different levels of vermicompost applications (Table-2). The highest yield (2.66 t ha-1) was found from Vm1 treatment which was statistically similar to Vm2 and Vm3 treatment and the lowest (1.91 and 1.83 t ha-1) was found in Vm4 and Vm5,respectively. Combinedly, a non-significant (*P* =NS) variation was found among the treatment against non-marketable yield of potato tubers (Table-3). But, numerically the highest yield (3.21 t ha-1) was found from V4Vm1 treatment combination while the lowest (1.44 t ha-1) was in V4Vm5 which was similar to numerically V4Vm4, V3Vm5, V3Vm4, V2Vm5 and V2Vm4.

**Table 1. Effect of potato varieties on the yield of potato in Bangalesh**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Varieties** | **Number of tubers hill-1** | **Average weight of tuber (g)** | **Weight of tubers hill-1 (g)** | **Tuber yield** **(t ha-1)** | **Marketable yield** **(t ha-1)** | **Non-marketable yield** **(t ha-1)** |
| V1 | 13.484 a | 30.693 c | 418.78 c | 24.63 b | 21.88 d | 2.75 a |
| V2 | 13.327 a | 33.871 b | 438.55 b | 28.87 a | 26.59 b | 2.28 a |
| V3 | 11.155 b | 49.069 a | 472.15 a | 28.38 a | 26.64 a | 1.74 b |
| V4 | 10.273 c | 48.365 a | 461.16 a | 28.79 a | 26.41 c | 2.38 a |
| **CV (%)** | 3.71 | 3.08 | 2.89 | 8.46 | 2.57 | 25.64 |
| **LSD (0.05)** | 0.4003 | 1.1148 | 11.559 | 2.0926 | 0.4252 | 2.1007 |
| **Significance level** | \*\* | \*\* | \*\* | \*\* | \*\* | \*\* |

Values with common letter (s) within a column do not differ significantly at 5% level of probability

\*\* indicates significant at 1% level of probability

V1= BARI Alu-68 (Atlantic), V2= BARI Alu-29 (Courage), V3= BARI Alu-25 (Asterix) and V4= BARI Alu-28 (Lady rosetta)

**Table 2. Effect of potato varieties levels of vermicomposting on the yield of potato in Bangalesh**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Vermicompost** | **Number of tubers hill-1** | **Average weight of tuber (g)** | **Weight of tubers hill-1 (g)** | **Tuber yield** **(t ha-1)** | **Marketable yield** **(t ha-1)** | **Non-marketable yield (t ha-1)** |
| Vm1 | 12.871 a | 36.969 b | 427.33 b | 25.25 b | 22.59 c | 2.66 a |
| Vm2 | 12.664 a | 37.207 b | 433.17 b | 25.72 b | 23.13 bc | 2.58 a |
| Vm3 | 13.062 a | 34.747 b | 420.12 b | 25.66 b | 23.19 b | 2.46 a |
| Vm4 | 10.944 b | 45.827 a | 478.08 a | 30.97 a | 29.06 a | 1.91 b |
| Vm5 | 10.757 b | 47.747 a | 479.57 a | 30.75 a | 28.92 a | 1.83 b |
| **CV (%)** | 7.29 | 7.54 | 6.61 | 5.70 | 7.11 | 20.22 |
| **LSD (0.05)** | 0.7314 | 2.5407 | 24.599 | 1.3125 | 1.0943 | 1.5416 |
| **Significance level** | \*\* | \*\* | \*\* | \*\* | \*\* | \*\* |

Values with common letter (s) within a column do not differ significantly at 5% level of probability

\*\* indicates significant at 1% level of probability

Vm1= 0 t ha-1, Vm2= 3 t ha-1, Vm3= 6 t ha-1, Vm4= 9 t ha-1 and Vm5= 12 t ha-1

**Table 3. Synergistic effect of potato varieties and vermicompost additions on the yield of potato in Bangaldesh**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Combination** | **Number of tubers hill-1** | **Average weight of tuber (g)** | **Weight of tubers hill-1 (g)** | **Tuber yield****(t ha-1)** | **Marketable yield****(t ha-1)** | **Non-marketable yield****(t ha-1)** |
| V1Vm1 | 14.113 a | 29.207 d | 408.12 de | 24.78 b | 21.84 e | 2.94 |
| V1Vm2 | 13.547 ab | 30.117 d | 415.44 cd | 24.38 b | 21.60 e | 2.77 |
| V1Vm3 | 13.617 ab | 31.107 d | 423.72 cd | 24.59 b | 21.87 de | 2.72 |
| V1Vm4 | 13.037 ab | 30.887 d | 425.11 cd | 24.98 b | 22.21 de | 2.77 |
| V1Vm5 | 13.107 ab | 32.147 d | 421.49 cd | 24.45 b | 21.86 de  | 2.58 |
| V2Vm1 | 12.977 ab | 32.107 d | 416.79 cd | 24.69 b | 22.07 de | 2.61 |
| V2Vm2 | 13.287 ab | 32.587 d | 436.45 cd | 25.99 b | 23.31 cd | 2.67 |
| V2Vm3 | 14.017 a | 33.187 d | 439.21 cd | 26.72 b | 23.92 cd | 2.79 |
| V2Vm4 | 14.007 a | 32.887 d | 460.79 bc | 33.56 a | 31.89 a | 1.66 |
| V2Vm5 | 12.347 bc | 38.587 c | 439.49 cd | 33.42 a | 31.75 a | 1.66 |
| V3Vm1 | 13.147 ab | 40.247 c | 451.15 cd | 24.76 b | 22.88 bc | 1.87 |
| V3Vm2 | 12.877 ab | 43.117 bc | 444.44 cd | 26.33 b | 24.45 b | 1.88 |
| V3Vm3 | 13.207 ab | 42.587 bc | 451.19 cd | 25.95 b | 24.21 b | 1.73 |
| V3Vm4 | 7.877 e | 60.247 a | 501.12 ab | 32.53 a | 30.95 a | 1.58 |
| V3Vm5 | 8.667 e | 59.147 a | 512.83 a | 32.35 a | 30.70 a | 1.64 |
| V4Vm1 | 11.247 cd | 46.317 b | 433.25 cd | 26.78 b | 23.56 de | 3.21 |
| V4Vm2 | 10.947 d | 43.007 bc | 436.36 cd | 26.17 b | 23.15 de | 3.02 |
| V4Vm3 | 11.407 cd | 32.107 d | 366.38 e | 25.39 b | 22.77 de  | 2.61 |
| V4Vm4 | 8.857 e | 59.287 a | 525.31 a | 32.82 a | 31.20 a | 1.62 |
| V4Vm5 | 8.907 e | 61.107 a | 544.49 a | 32.79 a | 31.34 a | 1.44 |
| **CV (%)** | 7.29 | 7.54 | 6.61 | 5.70 | 7.11 | 2.9425 |
| **LSD (0.05)** | 1.3668 | 4.6761 | 45.457 | 3.1324 | 2.0020 | ------- |
| **Significance level** | \*\* | \*\* | \*\* | \*\* | \*\* | NS |

Values with common letter (s) within a column do not differ significantly at 5% level of probability

 \*\* indicates significant at 1% level of probability; NS=Non-significant

 V1= BARI Alu-68 (Atlantic), V2= BARI Alu-29 (Courage) , V3= BARI Alu-25 (Asterix) and V4= BARI Alu-28

(Lady rosetta) Vm1= 0 t ha-1, Vm2= 3 t ha-1, Vm3= 6 t ha-1, Vm4= 9 t ha-1 and Vm5= 12 t ha-1

**3.7 Specific gravity (g cm-3)**

Specific gravity of tuberswas found non-significant (*P* =NS) against different potato varieties (Table-4). In respects of specific gravity of potato tubers also a non-significant (*P* =NS) response was noted against different levels of vermicompost applications (Table-5). Combindly, a significant variation (*P* ≤0.05) was found among the treatment against specific gravity of potato tubers (Table-6). The maximum specific gravity (1.1127 g cm-3) of tuber was found from V3Vm5 treatment combination which was statistically similar to rest all treatment combinations while the lowest (0.7247 g cm-3) specific gravity was found in V1Vm1 treatment combination. High specific gravity is an essential processing quality factor for potato and increased with increasing vermicompost level (Ferdous *et al*., 2020). So, the present result is in agreement with this citation.

**3.8 Dry matter content (%)**

A significant (*P* ≤0.01) difference was found among the varieties against dry matter content of potato tuber ( Table-4). The highest (20.165 %) dry matter content was found in V2 treatment which was statistically similar to V3 and V4 treatment while the lowest (17.267 %) dry matter was in V1. In respects of dry matter content of potato tubers also a significant (*P* ≤0.01) response was noted against different levels of vermicompost applications (Table-5). The highest dry matter (21.287 %) was found from Vm5 treatment which was statistically similar to Vm4 treatment and the lowest (17.367 %) was in Vm1. Combindly, a significant (p≤0.01) variation was found (Table-6) among the treatment against dry matter content of potato tubers. The highest dry matter (22.803 %) of tuber was found from V2Vm5 treatment combination which was statistically similar to V2Vm4, V3Vm4, V3Vm5, V4Vm4 and V4Vm5 while the lowest (16.120 %) dry matter was found in V1Vm1 treatment combination. High dry matter content (%) was observed which might be due to the application of high rate of vermicompost which played an important role in affecting the dry matter of tubers (Ferdous *et al*., 2020).

**3.9 TSS (Total soluble solid, obrix)**

A significant (*P* ≤0.01) difference was found among the varieties against total soluble solid of potato tuber (Table-4). The highest (6.478°) TSS was found in V4 treatment while the lowest (4.612°) TSS was in V1. In respects of TSS of potato tubers also a significant response was noted against different levels of vermicompost applications (Table-5). The highest TSS (6.111°) was found from Vm5 treatment which was statistically similar to Vm4 treatment and the lowest (5.271°) was in Vm1. Combindly, a significant (*P* ≤0.01) variation was found among the treatment against TSS of potato tubers ( Table-6). The highest TSS (7.1067°) of tuber was found from V4Vm4 treatment combination which was statistically similar to V4Vm5, V3Vm4 and V3Vm5 while the lowest (4.146°) TSS was found in V1Vm1 treatment combination. Higher portioning of photosynthate to tuber resulted in high dry matter content may be main reason for maximum total soluble solid content in tuber.

**3.10 Starch content (mg g-1 FW)**

A significant (*P* ≤0.01) difference was found among the varieties against starch content of potato tuber (Table-4). The highest (22.719 mg g-1 FW) starch content was found in V3 treatment followed by V3 while the lowest (16.67 mg g-1 FW) was in V1. In respects of starch content of potato tubers also a significant response (*P* ≤0.01) was noted against different levels of vermicompost applications (Table-5). The highest starch (22.244 mg g-1 FW) was found from Vm5 treatment which was statistically similar to Vm4 treatment and the lowest (18.287 mg g-1 FW) was in Vm1. Combindly, a significant (*P* ≤0.01) variation was found among the treatment against starch content of potato tubers (Table-6). The highest starch (26.007 mg g-1 FW) of tuber was found from V3Vm4 treatment combination which was statistically similar to V3Vm5, V4Vm4 and V4Vm5 while the lowest (16.337 mg g-1 FW) starch was found in V1Vm1 treatment.

**3.11 Reducing sugar (mg g-1 FW)**

A significant (*P* ≤0.01) difference was found among the varieties against reducing sugar content of potato tuber (Table-4). The highest (0.516 mg g-1 FW) reducing sugar content was found in V1 treatment followed by V2 while the lowest (0.298 mg g-1 FW) reducing content was in V3. In respects of reducing sugar content of potato tubers also a significant (*P* ≤0.01) response was noted against different levels of vermicompost applications (Table-5). The highest reducing sugar (0.456 mg g-1 FW) was found from Vm1 treatment followed by Vm3 treatment and the lowest (0.326 mg g-1 FW) was in Vm4. Combindly, a significant (*P* ≤0.01) variation was found among the treatment against reducing sugar content of potato tubers (Table-6). The highest reducing sugar (0.5467 mg g-1 FW) of tuber was found from V1Vm1 treatment combination which was statistically similar to V1Vm2 and V1Vm5 while the lowest (0.2367 mg g-1 FW) reducing sugar was found in V4Vm4 treatment combination which was statistically similar to V4Vm5 and V3Vm5.

**Table 4. Effect of potato varieties on the qualities of potato in Bangaldesh**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Varieties** | **Specific gravity****( g cm-3)** | **Dry matter content****(%)** | **Total soluble solid****(obrix)** | **Starch content****(mg g-1 FW)** | **Reducing sugar****(mg g-1 FW)** |
| V1 | 0.971 | 17.267 b | 4.612 d | 16.67 d | 0.516 a |
| V2 | 0.983 | 20.165 a | 5.302 c | 18.63 c | 0.418 b |
| V3 | 1.057 | 19.358 a | 6.202 b | 22.719 a | 0.298 d |
| V4 | 1.054 | 19.759 a | 6.478 a | 21.901 b | 0.343 c |
| **CV (%)** | 11.59 | 8.21 | 2.55 | 2.17 | 3.48 |
| **LSD (0.05)** | ------ | 1.4037 | 0.1287 | 0.3876 | 0.0123 |
| **Significance level** | NS | \*\* | \*\* | \*\* | \*\* |

Values with common letter (s) within a column do not differ significantly at 5% level of probability

\*\* indicates significant at 1% level of probability V1= BARI Alu-68 (Atlantic), V2= BARI Alu-29 (Courage) , V3= BARI Alu-25 (Asterix) and V4= BARI Alu-28 (Lady rosetta)

**Table 5. Effect of vermicompost on the qualities of potato in Bangalesh**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Vermicompost** | **Specific gravity****( g cm-3)** | **Dry matter content****(%)** | **Total soluble solid****(obrix)** | **Starch content****(mg g-1 FW)** | **Reducing sugar****(mg g-1 FW)** |
| Vm1 | 0.958 | 17.367 b | 5.271 b | 18.287 b | 0.456 a |
| Vm2 | 1.032 | 17.742 b | 5.304 b | 18.314 b | 0.394 c |
| Vm3 | 1.031 | 17.786 b | 5.524 b | 19.074 b | 0.430 b |
| Vm4 | 1.062 | 21.504 a | 6.034 a | 21.994 a | 0.326 e |
| Vm5 | 0.997 | 21.287 a | 6.111 a | 22.244 a | 0.364 d |
| **CV (%)** | 13.07 | 3.81 | 5.57 | 4.80 | 5.70 |
| **LSD (0.05)** | ------- | 0.6066 | 0.2616 | 0.7975 | 0.0187 |
| **Significance level** | NS | \*\* | \*\* | \*\* | \*\* |

Values with common letter (s) within a column do not differ significantly at 5% level of probability

\*\* indicates significant at 1% level of probability

Vm1= 0 t ha-1, Vm2= 3 t ha-1, Vm3= 6 t ha-1, Vm4= 9 t ha-1 and Vm5= 12 t ha-1

**Table 6. Synergistic effect of potato varieties and levels of vermicomposting on the qualities of potato in Bangalesh**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Combination** | **Specific gravity****( g cm-3)** | **Dry matter content** **(%)** | **Total soluble solid** **(obrix)** | **Starch content** **(mg g-1 FW)** | **Reducing sugar****(mg g-1 FW)** |
| V1Vm1 | 0.7247 b | 16.120 d | 4.1467 h | 16.337 d | 0.5467 a |
| V1Vm2 | 1.0227 a | 16.833 d | 4.2167 h | 16.387 d | 0.5167 ab |
| V1Vm3 | 1.0417 a | 17.436 bcd | 4.5067 h | 16.747 d | 0.4967 bc |
| V1Vm4 | 1.0227 a | 17.947 bcd | 5.0467 g | 16.917 d | 0.5067 bc |
| V1Vm5 | 1.0437 a | 18.000 bc | 5.1467 fg | 17.007 d | 0.5167 ab |
| V2Vm1 | 1.0507 a | 18.303 bc | 5.2867 efg | 17.107 d | 0.4567 def |
| V2Vm2 | 1.0547 a | 19.180 b | 5.3067 d-g | 17.277 d | 0.4267 f |
| V2Vm3 | 1.0317 a | 18.060 bc | 5.7067 b-e | 19.317 c | 0.4567 def |
| V2Vm4 | 1.0437 a | 22.477 a | 5.0067 g | 19.247 c | 0.3067 hi |
| V2Vm5 | 0.7353 b | 22.803 a | 5.2067 efg | 20.217 bc | 0.4467 ef |
| V3Vm1 | 1.0287 a | 17.309 bcd | 5.6467 b-e | 20.187 bc | 0.3367 gh |
| V3Vm2 | 1.0267 a | 16.950 bcd | 5.6067 c-f | 20.207 bc | 0.3667 g |
| V3Vm3 | 1.0277 a | 17.697 bcd | 5.7767 bcd | 21.347 b | 0.2867 ij |
| V3Vm4 | 1.0917 a | 22.647 a | 6.9767 a | 26.007 a | 0.2567 jk |
| V3Vm5 | 1.1127 a | 22.190 a | 7.0067 a | 25.847 a | 0.2467 k |
| V4Vm1 | 1.0287 a | 17.737 bcd | 6.0067 bc | 19.517 c | 0.4867 bcd |
| V4Vm2 | 1.0277 a | 18.003 bc | 6.0867 bc | 19.387 c | 0.2667 jk |
| V4Vm3 | 1.0257 a | 17.953 bcd | 6.1067 b | 18.887 c | 0.4800 cde |
| V4Vm4 | 1.0907 a | 22.947 a | 7.1067 a | 25.807 a | 0.2367 k |
| V4Vm5 | 1.0987 a | 22.153 a | 7.0867 a | 25.907 a | 0.2467 k |
| **CV (%)** | 13.07 | 3.81 | 5.57 | 4.80 | 5.70 |
| **LSD (0.05)** | 0.2233 | 1.7669 | 0.4848 | 1.4770 | 0.0356 |
| **Significance level** | \* | **\*\*** | \*\* | \*\* | \*\* |

Values with common letter (s) within a column do not differ significantly at 5% level of probability

\*\* indicate significant at 1% level of probability; \* indicates significant at 5% level of probability; NS=Non-significant

V1= BARI Alu-68 (Atlantic), V2= BARI Alu-29 (Courage) , V3= BARI Alu-25 (Asterix) and V4= BARI Alu-28 (Lady rosetta)

Vm1= 0 t ha-1, Vm2= 3 t ha-1, Vm3= 6 t ha-1, Vm4= 9 t ha-1 and Vm5= 12 t ha-1

**3.12 Correlation co-efficient (r)**

A strong negative correlation (r=−0.917) was found between the number of tuber and average weight of tuber (Figure-1). In Figure-2, a positive correlation (r=0.881) was observed between average weight of tuber and weight of tuber per hill. A week but positive relation (r=0.172) was found between specific gravity and dry matter content of potato tuber (Figure-3). A positive relation (r=0.606) was found between dry matter content and Total Soluble Solid (TSS) of potato tuber (Figure-4). In Figure-5, a positive relation (r=0.537) was found between specific gravity and Total Soluble Solid (TSS) of tuber. A strong negative relation (r=−0.849) was found between starch and reducing sugar content of potato tuber (Figure-6).

**Figure 1. Relationship between number of tuber hill-1 and average weight of tuber (g)**

**Figure 2. Relationship between average weight of tuber (g) and weight of tuber hill-1**

**Figure 3. Relationship between specific gravity (g cm-3) and tuber dry matter**

 **content (%)**

**Figure 4. Relationship between tuber dry matter content (%) and TSS (°brix)**

**Figure 5. Relationship between specific gravity of tuber (g cm-3) and TSS (°brix)**

**Figure 6. Relationship between starch content (mg g-1 FW) and reducing sugar content of potato (mg g-1 FW)**

**Conclusions**

The results indicated significant variations in several key parameters due to both the variety of potatoes and the levels of vermicompost applied. Notably, the number of tubers per hill, average weight of tubers, weight of tubers per hill, tuber yield, marketable yield, and non-marketable yield were all significantly influenced by the treatments. The highest yields and quality metrics were generally observed with two levels of vermicompost application (i.e. 9 and 12 t ha⁻¹). While specific gravity did not show significant variation across varieties or vermicompost levels, other quality parameters such as dry matter content, TSS, starch content, and reducing sugar content exhibited significant differences. Higher vermicompost levels generally resulted in improved dry matter content, TSS, and starch content, which are crucial for processing quality. Correlation analysis revealed important relationships between various yield and quality parameters. A strong negative correlation was found between the number of tubers per hill and the average weight of tubers, indicating a trade-off between these two metrics. Positive correlations were observed between average weight of tubers and weight of tubers per hill, as well as between dry matter content and TSS. A strong negative correlation between starch content and reducing sugar content was also noted. In conclusion, the application of vermicompost at higher levels significantly enhanced the yield and processing quality of potatoes. The study highlights the potential of vermicompost as a sustainable and effective soil amendment for improving potato production in Bangladesh. These findings can guide farmers and agricultural practitioners in optimizing vermicompost use to achieve higher yields and better-quality potatoes, thereby enhancing their economic returns. Further research could explore the long-term effects of vermicompost application and its interaction with other agronomic practices to refine potato cultivation strategies in the region.

**Competing Interests**

The authors declare that there is no conflict of interest regarding the publication of this paper. The research was conducted independently, and no financial or personal relationships influenced the results or interpretation of the data. All authors have reviewed the manuscript and agreed to its submission for publication.

**Abbreviations**

AEZ = Agro Ecological Zone

TCRC = Tuber Crop Research Centre

BARI = Bangladesh Agricultural Research Institute

BADC = Bangladesh Agricultural Development Corporation

TSP = Triple Super Phosphate

MoP = Muriate Of Potash

DAP = Di-Ammonium Phosphate

SL = Soluble Concentrate

EC = Emulsifiable Concentrate

FW = Formula Weight

DMC = Dry Matter Content

TSS = Total Soluble Solid

AOAC = Association of Official Agricultural Chemists

ERMA = European Raw Materials Alliance

ANOVA = Analysis of Variance

WASP = Wed Agri Stat Package

LSD = Least significant difference

NS = Non Significant

CV = Coefficient of Variation

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**References:**

1. Alam, Q., & Baset, M. (2009). Potato for food security in Bangladesh.
2. Al-Maamori, H., Salman, A., Al-Budeiri, M., Al-Shami, Y., & Al-Shaabani, E. (2023). Effect of vermicompost production on some soil properties and nutrients in plants. *IOP Conference Series: Earth and Environmental Science*, 1214.
3. Association of Official Analytical Chemists. (1990). *Official methods of analysis* (15th ed.). Washington, DC: Author.
4. Badrunnesa, A., Chakraborty, R., Chakraborty, E., & Roy, T. (2021). Biochemical and sensory traits of potato for processing purpose as influenced by vermicompost and potassium sources. *International Journal of Agricultural and Applied Sciences*.
5. Barman, K., Kumar, A., Kasera, S., & Ram, B. (2018). Integrated nutrient management in potato ( *Solanum tuberosum* ) cv . *Kufri Ashoka*. .
6. Birch, P., Bryan, G., Fenton, B., Gilroy, E., Hein, I., Jones, J., Prashar, A., Taylor, M., Torrance, L., & Toth, I. (2012). Crops that feed the world 8: potato: are the trends of increased global production sustainable?. *Food Security*, 4, 477 - 508.
7. Camire, M., Kubow, S., & Donnelly, D. (2009). Potatoes and human health. *Critical Reviews in Food Science and Nutrition*, 49, 823 - 840.
8. Campos, H., & Ortiz, O. (2019). The Potato Crop: Its Agricultural, Nutritional and Social Contribution to Humankind. *The Potato Crop*.
9. Ceritoğlu, M., Sahin, S., & Erman, M. (2018). Effects of vermicompost on plant growth and soil structure. *Selcuk Journal of Agricultural and Food Sciences*.
10. Chatterjee, R., Debnath, A., & Mishra, S. (2020). Vermicompost and Soil Health. , 69-88.
11. Das, R., & Deka, H. (2021). Vermicomposting of harvested waste biomass of potato crop employing *Eisenia fetida*: changes in nutrient profile and assessment of the maturity of the end products. *Environmental Science and Pollution Research*, 28, 35717 - 35727.
12. Devaux, A., Goffart, J., Kromann, P., Andrade-Piedra, J., Polar, V., & Hareau, G. (2021). *The Potato of the Future: Opportunities and Challenges in Sustainable Agri-food Systems. Potato Research*.
13. Devaux, A., Goffart, J., Petsakos, A., Kromann, P., Gatto, M., Okello, J., Suárez, V., & Hareau, G. (2020). Global food security, contributions from sustainable potato agri-food systems*. The Potato Crop*.
14. Doan, T., Henry-Des-Tureaux, T., Rumpel, C., Janeau, J., & Jouquet, P. (2015). Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: a three year mesocosm experiment.. *The Science of the total environment*, 514, 147-54 .
15. Ferdous, J., Roy, T., Chakraborty, R., Mostofa, M., Noor, R., Nowroz, F., & Kundu, B. (2020). Vermicompost influences processing quality of potato tubers. *SAARC Journal of Agriculture*, 17, 173-184.
16. Ferdous, J., Roy, T., Chakraborty, R., Mostofa, M., Nowroz, F., & Noor, R. (2019). Starch and sugar content of some selected potato varieties as influenced by vermicompost. *Azarian Journal of Agriculture*.
17. Gazi, A., Maity, A., Khatua, N., Sengupta, S., Kundu, S., & Sarkar, T. (2024). Effect of vermicompost on soil quality and crop productivity. *International Journal of Agriculture Extension and Social Development.*
18. Hossain, M. (2016). Forecasting potato production in Bangladesh by ARIMA model. *Journal of Animal Science*, 1.
19. Johnson, C., & Cheein, F. (2023). Machinery for potato harvesting: a state-of-the-art review. *Frontiers in Plant Science*, 14.
20. Kumar, V., , S., & Singh, J. (2020). Effect of vermicompost and phosphate solubilizing bacteria on growth and yield of potato (*Solanum tuberosum* L.). *Journal of Pharmacognosy and Phytochemistry*, 9, 1454-1456.
21. Lim, S., Wu, T., Lim, P., & Shak, K. (2015). The use of vermicompost in organic farming: overview, effects on soil and economics.. *Journal of the science of food and agriculture*, 95 6, 1143-56 .
22. Manivannan, S., Balamurugan, M., Parthasarathi, K., Gunasekaran, G., & Ranganathan, L. (2009). Effect of vermicompost on soil fertility and crop productivity--beans (Phaseolus vulgaris).. *Journal of environmental biology*, 30 2, 275-81 .
23. Manogna, A. (2021). A Review on potato cultivation.
24. Mostofa, M., Roy, T., & Chakraborty, R. (2021). Interactive Effects of vermicompost and seed tuber size on the production of potato (*Solanum tuberosum* L.). *Bangladesh Journal of Botany.*
25. Nelson, N. (1944). A photometric adaptation of the Somogyi method for the determination of glucose. *J. Biol. Chem*. 187: 375-380.
26. Porter, G., Bradbury, W., Sisson, J., Opena, G., & McBurnie, J. (1999). Soil management and supplemental irrigation effects on potato: I. soil properties, tuber yield, and quality. *Agronomy Journal*, 91, 416-425.
27. Qasim, M., Ju, J., Zhao, H., Bhatti̇, S., Saleem, G., Memon, S., Ali, S., Younas, M., Rajput, N., & Jamali, Z. (2023). Morphological and physiological response of tomato to sole and combined application of vermicompost and chemical fertilizers. *Agronomy*.
28. Rahmawati, N., Sitepu, F., & Pasaribu, M. (2022). Vermicompost application to increase sweet potato local genotype yield to support sustainable agriculture. *IOP Conference Series: Earth and Environmental Science*, 977.
29. Rehman, S., De Castro, F., Aprile, A., Benedetti, M., & Fanizzi, F. (2023). Vermicompost: enhancing plant growth and combating abiotic and biotic stress. *Agronomy*.
30. Robertson, T., Alzaabi, A., Robertson, M., & Fielding, B. (2018). Starchy carbohydrates in a healthy diet: the role of the humble potato. *Nutrients*, 10..
31. Roy, T., Chakraborty, R., Parvez, M., Biswas, S., & Chakraborty, S. (2017). Development of sustainable gross national income from potato export in Bangladesh- A perspective review. *Universal Journal of Agricultural Research*, 5, 46-51.
32. Sebayang, N., Sabrina, T., & Sari, R. (2022). Analysis the nutrient of bio-vermicompost with different techniques applications of some microbes and earthworms. *IOP Conference Series: Earth and Environmental Science*, 1059.
33. Tammam, A., Shehata, M., Pessarakli, M., & El-Aggan, W. (2022). Vermicompost and its role in alleviation of salt stress in plants – I. Impact of vermicompost on growth and nutrient uptake of salt-stressed plants. *Journal of Plant Nutrition*, 46, 1446 - 1457.
34. Yadava, L., Singh, J., Srivastava, D., Singh, S., Mishra, P., & Singh, H. (2024). Effect of humic acid and vermicompost on growth and yield of potato (*Solanum tuberosum* l.) cv. *Chipsona-1. Plant Archives*.
35. Zaheer, K., & Akhtar, M. (2016). Potato production, usage, and nutrition—a review. critical reviews in food science and nutrition, 56, 711 - 721.
36. Zakaria, N., Khoiri, N. M. A., & Hapsoh, N. (2022). Effect of super K organic fertilizer with various sizes of bulbs on growth and production of shallots (*Allium ascalonicum* L.). *International Journal of Science and Research Archive*, 5(2), 056–066.
37. Zeleke, A., & Getahun, B. (2024). Association and path coefficient analysis studies in potato (*Solanum tuberosum* L.) genotypes at Adet, Northwestern Ethiopia*. International Journal of Bio-resource and Stress Management*.