**Evaluation of Rabi Onion Varieties Based on Quantitative Attributes under Tripura Condition**

**Abstract**

**Background:** The cultivation of onion in Tripura is not a widespread practice. Tripura has a 38.42 thousand metric tonnes annual demand for onion, compared to a production of 1050 metric tonnes in 2018. The state's demand is fulfilled mainly by importing it from other states like Maharashtra, West Bengal. So for the purpose of meeting the demand of the common people and also for the development of a common source of income for the farmers, the experiment was conducted to find the appropriate variety(s) cultivation practice and best-high yielding variety(s) for the region. The experiment was performed in the Experimental Farm of College of Agriculture, Tripura, during the Rabi season of 2022-23 and 2023-24.

**Methods:** Twelve varieties of onion were taken viz., Sukhsagar, Bhima Kiran, Bhima Light Red, NHRDF Red-4, NHRDF Red-2, Fursungi, Bhima Red, NHRDF Red, Bhima Raj, Bhima Shweta, Agrifound Light Red and one check variety Bhima Shakti were evaluated using RCBD (Randomized Complete Block Design) with three replications.

**Results:** The experiment’s result showed that theSukhsagar was the best among promising standard performers, displaying the most desirable characteristics and low post-harvest neck thickness, which is remarkable for its long-term storage. Sukhsagar required the minimum days to harvest (103 days) which was followed by Bhima Red (106 days). Among the yield parameters the highest average weight was observed in variety Bhima Raj (59.93 g). In terms of total yield and marketable yield Sukhsagar was the maximum (26.29 t/ha) and (23.38 t/ha) respectively making it very commercial.

**Conclusion:** It can be concluded from the results of the experiment that for optimizing the yield, early harvest, Sukhsagar, Bhima Red, Bhima Shweta and Fursungi are recommended under Rabi season in the region.

***Key Words:*** *DMRT, FYM, Neck Thickness, Varieties, Yield.*

**Introduction**

Onion (*Allium cepa* L.) also called the "Queen of the Kitchen" is mostly used in cooking, medicine, trade, and as a source of income. The strong flavor of the onion comes from the volatile oil allylpropyl disulphide. Onion is the most widely cultivated species of the family alliaceae. Approximately 700 species of the genus *Allium* consists of perennial plants which are characterized by subterranean storage structures such as rhizomes or bulbs (Borborah *et al*., 2014; Sangade *et al*., 2023 ). Onion is esteemed and preserved as pickles for its flavor and nutritional benefits. The origin of Onion is believed to be in Afghanistan, Iran, or the USSR which is currently cultivated in over 175 countries (Suleria *et al*., 2015; Chakraborty *et al*., 2022). There are various phytomolecules found in onion, polyphenolic substances, phenolic acids, ascorbic acid, flavonoids (fisetin, quercetin), and sulfur compounds which are responsible for the color, flavor, and aroma, and also have health benefits like anti-toxic, anticarcinogenic qualities, antithrombotic, antiplatelet, antiasthmatic, and antibiotic effects, also the capacity to modulate detoxification systems (Dorrigiv *et al*., 2021). According to Watt and Merill (1950), onions contain eleven different amino acids. About 501 μg of vitamin A, 0.03 mg of thiamine, 0.04 mg of riboflavin, 0.02 mg of niacin and 9 mg of ascorbic acid are present in about 100 grams of raw onion bulbs. There are few trace minerals like iron, copper, zinc, and manganese present in onion. They are also rich in carbohydrates, soluble sugars, and small amounts of fiber and protein. The medicinal properties of onion includes strong antiviral and antibacterial properties which is due to the vitamin C and sulfur containing compounds. Onion are classified into 3 main groups such as: common onions, Aggregatum onions (like shallots), and Ever-Ready onions. In India the onion cultivation involves the growing of different species including the common onion (*Allium cepa*), multiplier onion(potato onion), shallots and the Egyptian onion which are grown by different methods of propagation.

Onions are classified into three forms based on the light conditions under which they produce bulb; these are long day, short day, and intermediate day. They are also divided on the basis of bulb colors into three groups: white, yellow and red. There are around 140 countries that cultivate onion with India being one of the top producers (FAOSTAT 2021). In India, the leading cultivator is Maharashtra followed by Madhya Pradesh and Gujarat. Onion is cultivated in three seasons; Kharif, Late Kharif and Rabi with 60% of the output generated in the Rabi season.

Onion cultivation in Tripura and agronomic climatic conditions are favorable, there is though limitation in onion farming and a drastic mismatch between demand and supply exists. With the demand standing at 38.42 thousand metric tonnes annually against an output of only 1050 metric tonnes in (NHB 2018), onions in Tripura are primarily sourced from outside the region. Due to the poor connectivity during monsoons there is price fluctuation which further aggravates the situation. So there is need to explore onion cultivation in Tripura, especially during the Rabi season when land remains fallow after rice harvest.

**Materials and Methods**

During the Rabi season of 2022-23 and 2023-24 the field experiment was conducted at the Experimental Farm of College of Agriculture, Tripura located in warm and humid sub-tropical climate of Agartala, Tripura in North-Eastern part of India [91.318146˚ East longitude, 23.910861˚ North latitude and 12.80 m altitude]. The soil of the experimental field was mainly acidic, including a moderate drainage system and uniform texture. The monsoon begins during the 1st week of June with an average rainfall of about 2200 mm.

The experiments were set up in a randomized block design with three replications.. The entire trial site was leveled and divided into 36 plots of 3 x2m (6 sqm). Seedlings were sowed at 15 x12 cm spacing between rows and plants. Fertilizer FYM @10-12 t/ha as basal dose along with half dose of Nitrogen (125kg/ha), full doses of P2O5 (75kg/ha) and full doses of K2O (75kg) was applied during field preparation. The remaining amount of Nitrogen (50Kg) was applied in two split doses the first being applied one month after transplanting and the second split was applied at 45 days after transplanting.

 Diverse varieties of Onion were collected from different sources employed for the present study. Total 12 varieties were selected, among which T12 (Bhima Shakti) was considered as check, since it was recommended for Zone-III(Tripura) by AICRP & AINRPOG, (Mahajan *et al*., 2018). The brief description of the Onion varieties under the study is presented in Table: 1.

The observations were recorded on ten randomly selected plant from each plot on growth and yield characters. The "Analysis of Variance" method was used to analyse the data collected The Duncan Multiple Range Test (DMRT) was used to differentiate and compare treatment means at a 5% level of significance.

**Table 1 : CHARACTERISATION OF ONION VARIETIES**

|  |  |  |
| --- | --- | --- |
| **Codes** | **Varieties** | **Source** |
| T1 | Sukhsagar | Local Market, West Bengal |
| T2 | Bhima Kiran | ICAR – Directorate of Onion and Garlic Research, Pune |
| T3 | Bhima Light Red | ICAR – Directorate of Onion and Garlic Research, Pune |
| T4 | NHRDF Red-4 | National Horticultural Research and Development Foundation (NHRDF) |
| T5 | NHRDF Red-2 | National Horticultural Research and Development Foundation (NHRDF) |
| T6 | Fursungi | National Horticultural Research and Development Foundation (NHRDF) |
| T7 | Bhima Red | ICAR – Directorate of Onion and Garlic Research, Pune |
| T8 | NHRDF Red | National Horticultural Research and Development Foundation (NHRDF) |
| T9 | Bhima Raj | ICAR – Directorate of Onion and Garlic Research, Pune |
| T10 | Bhima Shweta | ICAR – Directorate of Onion and Garlic Research, Pune |
| T11 | Agrifound Light Red | National Horticultural Research and Development Foundation (NHRDF) |
| T12 | Bhima Shakti | ICAR – Directorate of Onion and Garlic Research, Pune |



**Picture 1 : Characterization Of Onion Varieties**

**Results**

**Leaf Length (cm):**

The leaf length was measured and observation was taken at 30 Days fter Transplanting (DAT), 60 DAT and 90 DAT. The pooled data indicates that height was significantly differing at 30, 60 and 90 DAT. At 30 DAT highest leaf length was noted in variety Sukhsagar (43.84 cm) which is significantly higher than check (36.11 cm). At 60 DAT, highest leaf length was noted in variety NHRDF Red-4 (58.00 cm) which was statistically similar with Fursungi (57.55 cm), Bhima Kiran (56.72 cm), Sukhsagar (56.40 cm) and Bhima Shakti check as (56.03 cm). At 90 DAT, the range of leaf length varied from (49.59-58.49 cm), in which highest leaf length was observed on NHRDF Red-4 (58.49 cm) which was statistically similar to NHRDF Red (55.78 cm) and significantly higher than the (check)(Table2).

**Leaf Number Per Plant:**

At 30 DAT, the range of number of leaves per plant varied from (3.41-4.84) where the highest number of leaves per plant was recorded by Bhima Red (4.84) which was significantly higher than the check (3.69). At 60 DAT, the range of leaf number per plant varied from (4.54-5.92) where the highest leaf number per plant was observed on the variety Bhima Raj (5.92) which was statistically similar with Bhima Light Red (5.65) and significantly higher than the (check) The leaf number per plant at 90 DAT varied from (4.80-7.26) where the highest leaf number was found in the variety Bhima Raj (7.26) which was statistically similar with Bhima Shweta (7.04) and significantly higher than the check (5.32) (Table 2).

 **Neck Thickness (mm):**

At 30 DAT, the range of neck thickness varied from (4.02-6.45 mm) where the maximum neck thickness was observed in variety Fursungi (6.45 mm) which is statistically similar with Bhima Red (6.27) and significantly higher than the (check) On the other hand, minimum neck thickness was observed in NHRDF-Red (4.02 mm) which is statistically similar with ALR (4.21 mm). At 60 DAT, the range of neck thickness varied from (8.67-11.79 mm) where the maximum neck thickness was observed in variety Bhima Red (11.79 mm) which is statistically similar with Fursungi (11.42 mm) and Bhima Light Red (11.29 mm) and were found to be significantly higher than the check (9.64 mm). On the other hand, minimum neck thickness was observed in Sukhsagar (8.67 mm) which was found to be statistically similar with NHRDF-Red and Red-2-Br. At 90 DAT, the range of neck thickness varied from (8.10-13.30 mm) where the maximum neck thickness was observed in variety Bhima Light Red (13.30 mm) which is found to be statistically similar with Agrifound Light Red (12.97 mm), Fursungi (12.63 mm) and Bhima Kiran (12.49 mm). On the other hand, minimum neck thickness was observed in Sukhsagar (8.10 mm) which is significantly lower than the check (11.05 mm). (Table 2).

The neck thickness after harvest is a crucial factor in assessing the longevity of onion storage. Minimum neck thickness after harvest prevents from various storage diseases of onion, inhibits sprouting. The neck thickness after harvest of different varieties of onion ranged from (3.73-7.90 mm). The maximum neck thickness is observed in variety Fursungi and the minimum neck thickness was observed in Sukhsagar which is significantly lower than the (check). Bhima Shakti.

 **Equatorial Diameter (mm):**

The equatorial diameter of different varieties of onion ranged from (39.64-54.96 mm). The maximum equatorial diameter was observed on variety Bhima Raj which was significantly higher than the (check). The variety Sukhsagar (51.75 mm) and Agrifound Light Red (43.59 mm) also had medium bulb diameter (Table 3).

 **Polar Diameter (mm):**

The polar diameter of different varieties of onion ranged from (37.40-49.43 mm). The maximum polar diameter is observed in variety NHRDF-Red which was significantly higher than the check Sukhsagar (46.47 mm) also exhibited polar diameter next to NHRDF-Red (Table 3).

**Days to Harvest:**

Harvesting of onion done at the stage of physisiological when more than 80% of plants in a plot turn yellow, The number of days from transplanting to attainment of the physiological maturity were counted and recorded as day to maturity.

The days to harvestof the bulb of varieties of onion ranged from (103.50-118 days). The maximum days to harvest was observed in variety Bhima Raj which was statistically similar to NHRDF Red. The minimum days to harvest were recorded in Sukhsagar which is significantly lower than the check (110 days). Bhima Red (106.17 days) was next to Sukhsagar in number of days to harvest (Table 3).

 **Average Weight (g):**

The weight of bulb is an important quantitative parameter in determining the yield of the bulb. Bulb weight is a significant yield-related character.. The average weight of the bulb ranged from (39.31-59.93 g). The highest weight was observed in variety Bhima Raj (59.93 g) which was statistically similar with Sukhsagar (57.72 g). The lowest weight was observed in the variety Bhima Light Red (39.31 g) > (Table 3).

 **Total Yield (t/ha):**

 As presented in Table 3; the result showed that that the total yield of the bulb ranged from (18.63-25.26 t/ha.). The highest yield was observed in variety Sukhsagar which was statistically similar with Bhima Raj (24.40 t/ha) and were significantly higher than the check(18.67 t/ha).

**Marketable Yield (t/ha):**

The marketable yield of the bulb ranged from (15.85-23.38 t/ha.). The significant higher yield was obtained from Sukhsagar(23.38 t/ha) followed by Bhima Red (20.77 t/ha), Bhima Raj (20.37 t/ha) and Fursungi (20.25 t/ha) (Table 3).

**Discussion**

The highest leaf length was found in Sukhsagar and NHRDF Red-4 at different time period may be because of their genetic makeup and also the environment. Higher leaf length also suggests the ability of the plant to absorb nutrients from the soil and also photosynthetic ability. Similar findings were observed by Bal *et al*., (2020). Behera *et al*., (2017) observed that at 30 days after transplanting, leaf length ranged from 29.10 to 47.70 cm.The variation in the number of leaf per plant may be because of the genetics varietal differences, influence of the temperature, soil fertility and water. Similar findings were observed by Sarkar *et al.* (2015); Behera *et al*., (2017);Bal *et al*., (2020) where they have documented variations in the number of leaves per plant in onions varieties.

The minimum neck thickness found in sukhasagar which can be cured earlier and also be stored for longer duration. The neck thickness is closely related to the bulb forming process. During the transition from vegetative to the reproductive stage the neck begins to form. It can be also due to the interaction between the genetic makeup of the plant, environmental factors, growth stages and cultural practices. The results found here were similar to the findings by Gosai *et al.,* (2018);Prithiani *et al*., (2022).

The variation in the equatorial diameter of the bulb may be due to f their pattern of inheritance, each individual genotype has a unique genotypic composition and also environmental factors. A study conducted by Bindu and Podikunju (2015) showed that the largest bulb diameter was found in the variety Agrifound Dark Red, followed by Arka Kalyan and N-53. Gupta *et al*., (2019) also found variation in the equatorial diameter of the bulbs among diggerent onion varieties..

The variation in the polar diameter of the bulb may ascribed their pattern of inheritance, each individual genotype has a unique genotypic composition and also environmental factors. The result found in our experiment was in close conformity with the result of experiment conducted Dhar *et al.*, (2019) and Singh *et al*., (2021).

Harvesting of onion done at the stage when the number of days from seedling to transplanting and when more than 80% of plants in a plot show yellowing or reach physiological maturity (Tekle, 2015). The harvesting procedures used are governed by the weather conditions, unique genotypic composition and also environmental factors at harvest season (Patel *et al*., 2020). Similar research work of variation in the days to harvest has been done by Sharma *et al*., (2014) and Dubey *et al*., (2019). In our finding the minimum days to harvest was required by Sukhsagar which can be used to reach the market earlier and get higher price.

The studies done by Chattoo*et al*., (2015) found that fresh bulb weight had a favorable and direct effect on bulb yield. The equatorial and polar diameter of the bulb has a direct influence on the average weight of the bulb. Bhima Raj and Sukhsagar was having highest average bulb weight which may be due to their genetic makeup and environmental factors. Similar finding was reported by Gosai *et al.*, (2018) and Gupta *et al*., (2024).

In the finding of thses research Sukhsagar and Bhima Raj produced higher yields which may be due to improved vegetative growth, including increased plant height and leaf count, which improves photosynthetic efficiency. Similar research findings were reported by various author(Utag i*et al.,* 2015; Gosai *et al.*, 2018 and Mandal *et al*.,2019).

The highest total yield was obtained by Bhima Raj but in case of marketable yield, highest marketable yield was obtained from Sukhsagar as a result of many bulb of Bhima Raj were of pencil thickness, rotten and unmarketable bulbs which may be due to the soil and biotic and abiotic factors. These varieties produced higher marketable yields due to improved vegetative growth, such as plant height and leaf count, which improves photosynthetic efficiency. The significant variation in the marketable yield of the bulb among onion varieties was also observed by Gosai *et al.*, (2018);Jana *et al., (*2023) and Gupta *et al*., (2024). Bal *et al*., (2020) also recorded significant differences among the yield of different onion varieties..

**Table 2: Growth Attributes of different varieties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Varieties | Leaf Length (cm) | Leaf Number Per Plant | Neck Thickness (mm) | Neck Thickness after Harvest(mm) |
| **30 DAT** | **60 DAT** | **90 DAT** | **30 DAT** | **60 DAT** | **90 DAT** | **30 DAT** | **60 DAT** | **90****DAT** |
| Sukhsagar | **43.84a** | 56.40ab | 51.99cd | 4.50b | 5.22cde | **4.80e** | 6.00b | **8.67f** | **8.10g** | **3.73g** |
| Bhima Kiran | 37.31cd | 56.72ab | 51.83cd | 3.94cd | 5.14cde | 5.89c | 5.11c | 10.25b | 12.49abcd | 6.81cd |
| Bhima Light Red | 34.49ef | 54.52bc | 50.29d | **3.41f** | 5.65ab | 5.76c | 5.05c | 11.29a | **13.30a** | 7.09bc |
| NHRDF Red-4 | 41.01b | **58.00a** | **58.49a** | 3.74cde | 4.75fg | 5.83c | 5.22c | 9.95bc | 11.81cdef | 5.33f |
| NHRDF Red-2 | 37.13cd | **51.37d** | 51.56cd | 3.62ef | 4.89ef | 5.81c | 4.65d | 8.98def | 11.65def | 6.42de |
| Fursungi | 41.23b | 57.55a | 53.90bc | 3.97c | 5.36bc | 5.89c | **6.45a** | **11.42a** | 12.63abc | **7.90a** |
| Bhima Red | 38.46c | 53.92bcd | **49.59d** | **4.84a** | 5.48bc | 6.34b | 6.27ab | 11.79a | 12.15bcde | 5.57f |
| NHRDF Red | 31.77g | 52.30cd | 55.78ab | 3.67def | **4.54g** | 5.66cd | **4.02f** | 8.84ef | 11.92cdef | 5.26f |
| Bhima Raj | **31.72g** | 51.86cd | 52.47cd | 3.96cd | **5.92a** | **7.26a** | 4.52de | 9.48cde | 11.30ef | 6.25e |
| Bhima Shweta | 34.05ef | 53.74bcd | 55.78ab | 3.85cde | 5.50bc | 7.04a | 4.57de | 10.17bc | 12.14bcde | 7.23bc |
| Agrifound Light Red | 33.72fg | 52.08cd | 52.45cd | 3.75cde | 4.98def | 6.33b | 4.27ef | 10.19bc | 12.97ab | 6.95c |
| Bhima Shakti | 36.11de | 56.03ab | 51.79cd | 3.69cde | 5.27cd | 5.32d | 5.05c | 9.64bcd | 11.05f | 7.44b |
| SEM± | 0.73 | 0.94 | 0.93 | 0.09 | 0.12 | 0.14 | 0.12 | 0.23 | 0.28 | 0.16 |
| CD | 2.08 | 2.67 | 2.66 | 0.26 | 0.33 | 0.39 | 0.34 | 0.67 | 0.80 | 0.45 |
| CV | 4.86 | 4.20 | 4.32 | 5.67 | 5.48 | 5.64 | 5.65 | 5.71 | 5.81 | 6.06 |

**Table 3: Yield Attributes**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Varieties | Equatorial Diameter (mm) | Polar Diameter (mm) | Days to Harvest | Average Weight (g): | Total Yield (t/ha) | Marketable Yield (t/ha) |
| Sukhsagar | 51.75b | 46.47b | **103.50f** | 57.72a | **25.26a** | **23.38a** |
| Bhima Kiran | 45.04cd | 41.93c | 110.33cd | 44.40cd | 21.03de | 18.08def |
| Bhima Light Red | 42.34e | 38.18d | 109.50cd | **39.31f** | **18.63f** | 16.14h |
| NHRDF Red-4 | 43.08de | **37.40d** | 113.33b | 44.64cd | 21.91cde | 19.00cde |
| NHRDF Red-2 | 41.11ef | 42.30c | 110.50cd | 43.58de | 18.77f | **15.85h** |
| Fursungi | **39.64f** | 43.75c | 111.00c | 43.92de | 22.52bcd | 20.25bc |
| Bhima Red | 42.38e | 40.86c | 106.17e | 47.80bc | 23.16bc | 20.77b |
| NHRDF Red | 46.53c | **49.93a** | 116.50a | 49.35b | 20.41ef | 17.65efg |
| Bhima Raj | **54.96a** | 43.20c | **118.00a** | **59.93a** | 24.40ab | 20.37bc |
| Bhima Shweta | 43.40de | 42.19c | 108.83d | 50.64b | 22.87bcd | 19.19cd |
| Agrifound Light Red | 49.72b | 43.59c | 109.83cd | 41.69def | 20.42ef | 17.54fg |
| Bhima Shakti | 47.13c | 41.39c | 110.00cd | 40.64ef | 18.67f | 16.41gh |
| SEM | 0.84 | 0.89 | 0.65 | 1.14 | 0.61 | 0.46 |
| CD | 2.38 | 2.55 | 1.85 | 3.26 | 1.74 | 1.30 |
| CV | 4.49 | 5.14 | 1.44 | 5.97 | 6.97 | 5.95 |

**Figure 2. label**

**Correlation Studies**

The correlation study presented (in Table 4 ) revealed that marketable yield highly significantly and positively correlated with the average bulb weight and the total yield). In addition, the plant height), leaf number), equatorial diameter and polar diameter (also positively correlated with the marketable yield. The neck diameter significantly amd negatively correlated with the marketable yield.

Dewangan and Sahu (2014) discovered a notable positive correlation between marketable yield, total yield, and average bulb weight. Similarly, Aliyu *et al*. (2007); Nikhil *et al*. (2016) reported comparable findings, linking average bulb weight with bulb yield. A study conducted by Gupta *et al.*, (2024) found that the total yield and average bulb weight hada strong, significant positive correlation with marketable yield. He also observed that neck thickness (-double bulbs and bolter bulbs had a significant negative association with with marketable yield.

**Table 4: Correlation between Marketable Yield and its Components.**

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|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Plant Height | Leaf Number | Neck Diameter | Equatorial Diameter | Polar Diameter | Average Bulb Weight | Total Yield | Marketable Yield |
| Plant Height | 1.00 |  |  |  |  |  |  |  |
| Leaf Number | 0.10 | 1.00 |  |  |  |  |  |  |
| Neck Diameter | 0.01 | 0.47 | 1.00 |  |  |  |  |  |
| Equatorial Diameter | -0.09 | 0.11 | -0.52 | 1.00 |  |  |  |  |
| Polar Diameter | 0.08 | -0.17 | -0.38 | 0.40 | 1.00 |  |  |  |
| Average Bulb Weight | 0.11 | 0.26 | -0.64\* | 0.65\* | 0.47 | 1.00 |  |  |
| Total Yield | 0.15 | 0.25 | -0.52 | 0.42 | 0.25 | 0.84\*\* | 1.00 |  |
| Marketable Yield | 0.06 | 0.01 | -0.60\* | 0.35 | 0.27 | 0.75\*\* | 0.96\*\* | 1.00 |

**Conclusion:**

It was concluded that among the 12 varieties studied in Tripura for various growth and yield parameters Sukhsagar, Bhima Red, Bhima Shweta, and Fursungi showed significant potential for optimizing onion yield. Additionally, Sukhsagar, with its minimum neck thickness, is particularly suitable for long-term storage. Under the climatic conditions of Tripura Sukhsagar, Bhima Red, Bhima Shweta, and Fursungi exhibit superior performance among all the varieties in the experiment.

In accordance with the existing deficit between onion production and consumption in Tripura these findings present a valuable opportunity for local farmers especially during the Rabi season when land remains fallow after rice harvest. The gap between production and consumption can be minimized by the adoption of these high-yielding varieties. This in turn could be able to meet the growing local demand for onion and also serve as a viable income-generating opportunity for farmers in the region. Therefore, cultivating these varieties offers a promising strategy for both improving local onion production and enhancing the economic welfare of farmers in Tripura.

**Ethics Approval**

Not applicable

**References:**

Bal, S., Maity, T. K., & Maji, A. (2020). Evaluation of onion genotypes for growth, yield, and quality traits under Gangetic alluvial plains of West Bengal. International Journal of Chemical Studies, 8, 2157–2162.

Behera, T. K., Mandal, J., Mohanta, S., Padhiary, A. K., Behera, S., Behera, D., & Rout, R. K. (2017). Assessment of growth, yield and quality of onion genotypes under red and laterite zone of West Bengal. Journal of Pharmacognosy and Phytochemistry, 6(6), 493- 497.

Borborah, K., Dutta, B., & Borthakur, S. K. (2014). Traditional uses of Allium L. species from North East India with special reference to their pharmacological activities. American Journal of Phytomedicine and Clinical Therapeutics, 2(8), 1037-1051.

Chakraborty, A. J., Uddin, T. M., Matin Zidan, B. R., Mitra, S., Das, R., Nainu, F., ... & Emran, T. B. (2022). Allium cepa: A treasure of bioactive phytochemicals with prospective health benefits. Evidence-Based Complementary and Alternative Medicine, 2022(1), 4586318.

Chattoo, M. A., Angrej, A., & Kamaluddin. (2015). Genetic variability, interrelationship, and path analysis for yield and yield-related traits in onion (*Allium cepa* L.) under temperate conditions in Kashmir Valley. Plant Archives, 15(2), 1161-1165.

Dhar, M., Mandal, J., Maity, T. K., & Mohanta, S. (2019). Evaluation of kharif onion (Allium cepa L.) varieties under different planting dates. Journal of Pharmacognosy and Phytochemistry, 8(2), 1317-1321.

Dhotre, M., Allolli, T. B., Athani, S. I., & Halemani, L. C. (2010). Genetic variability, character association, and path analysis studies in Kharif onion (*Allium cepa* var. cepa L.). Asian Journal of Horticulture, 5(1), 143-146.

Dorrigiv, M., Zareiyan, A., & Hosseinzadeh, H. (2021). Onion (*Allium cepa*) and its main constituents as antidotes or protective agents against natural or chemical toxicities: A comprehensive review. Iranian Journal of Pharmaceutical Research, 20(1), 3.

Dubey, S., Verma, S., Chandrakar, K., & Keshari, R. (2019). Suitability of kharif onion varieties in Mahasamund district of Chhattisgarh. Journal of Krishi Vigyan, 7(2), 243-247.

FAO. (2021). World Food and Agriculture - Statistical Yearbook 2021. Rome.

Gautam, I. P., Khatri, B., & Paudel, G. P. (2006). Evaluation of different varieties of onion and their transplanting times for offseason production in mid hills of Nepal. Nepal Agricultural Research Journal, 7, 21-26.

Gorrepati, K., & Khade, Y. P. (2020). Onion and garlic keep us healthy. Indian Horticulture, 62(6).

Gosai, J. A., Rathawa, S. N., Dhakad, R. K., Jatav, A., & Verma, L. R. (2018). Evaluation of different varieties of onion (*Allium cepa* L.) under north Gujarat condition. International Journal of Current Microbiology and Applied Sciences, 7(5), 3775–3780.

Government of India. (2018). Horticultural statistics at a glance 2018. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare.

Gupta, A. J., Benke, A., Gorrepati, K., Mahajan, V., & Singh, M. (2024). Trait association and variability study for biochemical and yield related traits in onion (*Allium cepa* L.). Vegetable Science, 51(1), 49–55.

Gupta, N., Bhargav, K. S., & Dixit, A. K. (2020). Evaluation of Kharif onion (*Allium cepa* L.) varieties in Malwa agro-climatic zone of Madhya Pradesh. International Journal of Current Microbiology and Applied Sciences, 9(12), 2722–2727.

Jana, K., Thapa, U., Kundu, S., Hansda, N. N., Ray, K., & Tamang, D. (2023). Evaluation of different genotypes of late Kharif onion (*Allium cepa* L.) under the Gangetic plains of West Bengal, India. International Journal of Plant & Soil Science, 35(22), 295-305.

Mahajan, V., Gupta, A. J., Lawande, K. E., & Singh, M. (2018). Onion improvement in India. Journal of Allium Research, 1(1), 1-4.

Mandal, J., Ajgalley, R., Saha, D., & Mohanta, S. (2019). Growth, yield, and quality of onion cultivars under Laterite Belt of Eastern India. Vegetable Science, 46(1-2), 129-131.

Mohanty, B. K., & Prusti, A. M. (2002). Varietal screening of onion for kharif cultivation. Research on Crops, 3(1), 145-148.

Panse, V. G., & Sukhatme, P. V. (1967). Statistical methods for agricultural workers (2nd ed.). Indian Council of Agricultural Research.

Prithiani, S., Dighe, S. S., Jakhar, R. K., Pushpa, K., & Gautam, D. (2022). Evaluation of different varieties on growth characteristics of onion (*Allium cepa* L.). The Pharma Innovation Journal, 11(3), 386-388.

Sangade, D. A., Shaikh, M. K., & Sangpal, R. C. (2023). A review: Onion (*Allium cepa*). International Journal of Pharmaceutical Research and Applications, 8(6), 2305-2317.

Sarkar, R. K., Khagra, B. D., Pandit, T. K., Thapa, A. D., & Moktan, M. W. (2015). Evaluation of onion (*Allium cepa* L.) varieties for growth, yield, and quality traits under hill agro-climatic conditions of West Bengal. Environment and Ecology, 33(2A), 956-959.

Shah, S. T., Sajid, M., Alam, R., Rab, A., Mateen, A., Jan, I., & et al. (2012). Comparative study of onion cultivars at Mardan, Khyber Pakhtunkhwa - Pakistan. Sarhad Journal of Agriculture, 28(3), 399-402.

Sharma, D., Shukla, Y. R., & Jarial, K. (2014). Evaluation of onion varieties under low hill conditions of Himachal Pradesh. Journal of Horticultural Sciences, 9(1), 78–81.

Singh, D., Trivedi, J., Sharma, P. K., & Lodhi, Y. (2021). Evaluation of different onion (*Allium cepa* L.) genotypes for growth, yield, and quality parameters under Chhattisgarh plain region. The Pharma Innovation Journal, 10(9), 1646-1650.

Suleria, H. A. R., Butt, M. S., Anjum, F. M., Saeed, F., & Khalid, N. (2015). Onion: Nature protection against physiological threats. Critical Reviews in Food Science and Nutrition, 55(1), 50-66.

Tarai, R. K., Panda, P. K., Behera, S. K., & Beura, J. K. (2015). Varietal performance of onion in the western undulating zone of Odisha. International Journal of Scientific Research and Engineering, 2(1), 123-127.

Tekle, G. (2015). Growth, yield, and quality of onion (*Allium cepa* L.) as influenced by intra-row spacing and nitrogen fertilizer levels in central zone of Tigray, Northern Ethiopia. (Doctoral dissertation, Haramaya University, Oromia, Ethiopia).

Utagi, S., Anjanappa, M., Kale, S. M., & Badiger, M. (2015). Influence of different onion cultivars on storage life under the central dry zone of Karnataka. International Journal of Processing and Post Harvest Technology, 6(1), 36-40.

Watt, B. K., & Merrill, A. L. (1950). Composition of foods (Agriculture Handbook No. 8). USDA.