Original Article

Enhancing Anticancer Properties of Organosulfur Compounds in *Allium cepa* through Nitrogen, Sulfur, and Potassium Fortification in Barren Lands

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Abstract

Background: To fortify nutrients depleting loam being waste under murkiness and use it for enhancing anticancer food rationing in the human body, two onions (Allium cepa) cultivars i.e., Cv.1 and Cv.2 (locally called "imported and 144" respectively) were experienced. **Aims and Objectives:** The objective of this study was to evaluate the growth, yield, and anticancer nutrient potential of two onion cultivars under varying shaded conditions to explore their performance in depleted soils with added essential macronutrients. **Materials and Methods:** Fertilizers were applied at the rate of 50 kg of $NH_4(SO_4)_2$ and 25 kg of MOP (muriate of potash) per acre^{-1} with the first irrigation. Growth parameters were recorded under un-shaded, partially, and fully shaded canopies of Eugenia trees. **Results:** Maximum weights (162±9 g), horizontal diameters (7.83±0.77 cm), circumferences (24.20±2.4 cm), and number of leaves per plant (15±0.25) of onion bulbs were recorded in Cv.1 under shaded conditions followed by Cv.2 (weight 135±7 g, 7.82±1.01 cm, 22.5±2.2 cm, 14±0.92 respectively). Similarly, the maximum yield of bulbs (small and medium-sized) was 18±0.11 and 8.25±0.55 ton ha^{-1} in Cv.1 under un-shaded and 17±0.54 and 8.25±0.55 ton ha^{-1} under partially shaded conditions, while the lowest (6±0.36 ton ha^{-1}) was observed in large-sized bulbs under fully shaded conditions. More sprouting (40±2.1%) was observed under un-shaded, whereas least (18±3.5%) under partially shaded conditions in Cv.1. **Conclusion:** The response of both cultivars was beneficial under such an environment; however, Cv.1 was better. It was inferred from the results that onion, which is an excellent source of moderate levels of anticancer diet, can be obtained on these depleted soils by adding essential macronutrients.

Keywords: *Allium cepa* cultivars, cancer prevention, macronutrient enrichment, nutrient depleted soils

Introduction

Managing essential chemical nutrients in nutrients depleting and dissipating loams has a vital role to play in enhancing food medicinal values, especially in Pakistan which has a lot of such distressed patches in rural, urban, and squander areas of houses that can be consumed for this purpose. Most of our rural population are experienced in diseases[1] and malnutrition problems associated with in fertile soils. The urbanization and pollutions created by industries also causing changes in soil environment. Utilization of waste land for production of kitchen needs has now become an essential requirement of the time. Onion is a daily need of kitchen; biennial and its bulbs are the fleshy leaf bases with compact stem.[2] It produces a chemical compound (mostly custein sulfoxide) which gives them the typical smell and odor. Most of its leaves and bulbs are edible and also used in cooking and served as salad, especially, in Asian countries. China, India, USA, Japan, turkey, and Spain are the major producers of onion over the world. Onion is an essential part of the diets of all the Pakistani and like other vegetables; it provides vitamins such as Vitamin A and C, and a good amount of mineral elements to the human body.[3] In

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addition, onion is among the food plants to which moderate level of anticancer activities is associated with its rich content of bioactive compounds such as flavonoids, sulfur-containing compounds, and antioxidants that contribute to its health-promoting properties.[4] Studies have shown that increased consumption of onions reduces the risk of head-and-neck cancers. Onion is cultivated twice in a year with application of fertilizers, manure, compost, and different types of agricultural chemicals required for good yield by the farmers. Data on the nutrient composition in onions area are extensive and some studies also carried out to observe the effects of various fertilizers on the yield of onion and quality of its bulbs[5-7] but limited on waste, shaded, and nutrient depleted soils. In view of this, the present study was initiated on this nutrients deleting soil to augment rationing of *Allium cepa* to reduce the risk of cancer in our society.

The bioactive qualities of organosulfur compounds found in Allium species, such as *A. cepa* (onion), have demonstrated substantial potential as anticancer drugs.[8] Onions contain compounds called flavonoids and allicin, which have been shown to have the power to stop the cell cycle, suppress the growth of cancer cells, and cause apoptosis.[9] It is essential to prevent cancer and other diseases since these substances contain anti-inflammatory and antioxidant properties.[10] Research has time and again shown that the wide variety of organosulfur compounds found in allium vegetables provide a host of health benefits, including the prevention of cancer.[11]

Materials and Methods

The experimental studies were conducted at NIAB Campus area (1 acre) under the *Eugenia jambulana* trees along the road from main NIAB gate to the colony area. Before starting the experiment, all herb, shrubs, and weed were eradicated with the help of farm machinery and by farm laborers. Unwanted weeds and grasses were also discarded with the spray of weedicide (roundup). Experimental site was prepared by ploughing and rotavation using tractor three to four times to make sure it was satisfactory for experimentation. Preliminary two cultivars of onion, namely, Cv. 1 and Cv. 2 were grown with rows and plant to plant distances of 12″ and 6″, respectively, for acquiring the onion yields from waste lands lying under the canopies of *E. jambulana* trees. Onion seedlings were transplanted manually on the slopes of ridges at distances measured with marked ropes. First three irrigations were applied at the intervals of 8 days. After the transfer of seedlings, one bag of (NH4) 2SO4 (50 kg acre-1) and half bag of muriate of potash (25 kg acre-1) were applied with first irrigation. The experimental area was situated between latitude 31o 24o N, longitude 73o 1o E and height above the sea level 184 m. Soil samples were analyzed by using pH meter (8520, Hanna) and EC meter (LF 538, WTW, Germany).

Experimental soil was characterized with pHs 7.9–8.0, ECe 2.1–2.4 dS m^{-1}, organic matter (O. M.) 0.87%, total nitrogen (T. N.) 0.065%, soil NO3-N 7 ppm, available phosphorus 7–8 ppm, available potassium 270-276 ppm, and water holding capacity 29% with sandy clay loam texture. The micronutrients contents were analyzed on Atomic Absorption Spectrophotometer [Table 1]. During the study period, average day temperature ranged from 33°C to 41°C, night 25°C–30°C, relative humidity range from 40% to 50%, wind speed 1.22-1.50 m S-1 and mean air pressure 1300MPa. Randomize complete block design with split plots was established for this purpose. Site was divided into four blocks with two cultivars and three *E. jambulana* shade regimes namely, completely shaded, partially shaded and un-shaded. Means of twenty replicates from each row for both the cultivars were selected randomly and their weights were recorded by using balance (Sartorius Analytical Balance, Germany). The diameters of onions bulbs were recorded by Vernier caliper and the circumferences with the help of inches' tape. Compactness was calculated by using penetometer (0–11 lbs) and weight loss (%) and moisture contents (%) by putting small pieces of bulbs in small crucibles, dried them in a oven at 70 ± 1Co for 72 h and intermittently recorded their weights until they became constant. After harvesting, plant samples were put in refrigerators to avoid the moisture losses. The data obtained during the study period were analyzed by the statistically analysis system.[12] Significant differences were analyzed at 0.05 levels. Differences among means were ranked using Duncan's New Multiple Range Tests.[13,14]

Table 1: Atomic absorption spectrophotometric analysis of soils for Cr, Pb, Ni, and Cd concentration

Micronutrients	Range (μg g^{-1})	Average concentration (μg g^{-1})
Cr	14.6–15.5	15.05
Pb	11.9–12	11.95
Ni	17.2–18.2	17.7
Cd	0.2–0.6	0.4

Results and Discussions

Shade effects of *Eugenia jambulana* trees on bulb weights of the cultivars

Cultivars, shades, and blocks had significant ($P < 0.001$) effects on the weight of bulbs while interactions between cultivars and shade conditions (CXS) did not significantly ($P > 0.001$) affected the bulb weights. Results indicated consistently increasing trend from fully shaded, partially shaded to un-shaded in the yield of both the cultivars. Cv. 1 showed highest bulb weight of 162.62 g (ranged from 147.94 to 178.54 g) under the un-shaded conditions followed by partially shaded 70.28 g (ranged from 57.42 to 94.02 g) and shaded 40.47 g (ranged from 31.06 to 50.64 g). Similarly, in Cv. 2 weights of bulbs, gradually increased from un-shaded (135.12 g, ranged from 118.75 to 143.79 g), partially shaded (78.71 ± 2.47 g, ranged from 60.37 to 94.54 g), and under fully shaded (49.62 ± 3.20 g) conditions (ranged from 37.56 to 57.80 g). Both the cultivars of *A. cepa* showed the highest yield under unshaded while the lowest under fully shaded conditions of *E. jambulana* trees.

The bulb weight increased from 305% in unshaded and 75% for partially than fully shaded conditions. Similar in Cv. 1, the weight of onion bulb increased 175% under unshaded conditions of *E. jambulana* and 58.62% under partially conditions than weight of onion bulb grown under fully shaded conditions. Cv. 2 cultivar under fully shaded and partially shaded conditions gave better results, whereas under unshaded condition Cv. 1 cultivar gave better results. Bulbs under shaded conditions exhibited low weigh it might be due to the competitions between two producers, i.e., long and expanded root system of *E. jambulana* trees acquired more nutrition as compared to the small plants of onion. Environmental conditions such as sunlight, humidity, and air could also be the vital forces which were not freely available to onion plants.

Maximum weight of individual bulbs was recorded in onion Cv. 1 under unshaded condition (162.62 ± 9.10 g^{-1}) followed by onion Cv. 2 under unshaded (135.12 ± 7.40 g^{-1}) and partially shaded (78.71 ± 2.47 g^{-1}) while lowest in onion Cv. 1 under fully conditions (40.47 ± 3.20 g^{-1}). Maximum ranges were recorded in Cv. 1 (147.94-178.54 g) under unshaded followed by Cv. 2 (118.75-143.79) under unshaded conditions. Present results were similar to the findings of Ibrahim and Adesiyun[15] during the first transplanting with zero (161.0 g) and three sprays (160.0 g) than gradually weights decreased as date of transplanting increased. Bulb weight under unshaded conditions was higher than the values found by Yassen and Khalid[16] with application of various combinations of farm yard manure (FYM) and chicken manure (CM). Bulb weights in Cv. 2 under unshaded conditions were similar to the weights of smallest bulbs recorded by Abdelrazzag[17] with the introduction of 80 ton ha^{-1} CM and 80 ton ha-1 sheep manure.

Total yield of two culticars under three shaded conditions of *Eugenia jambulana* trees

Cultivars and interactions of cultivars and shades (CXS) had significant ($P < 0.001$) effects on total yield, whereas shades and blocks did not significantly affected the total yield. Maximum total yield was recorded in Cv. 1 under unshaded (31.79 ± 1.20 ton ha^{-1}) and partially shaded conditions (31.20 ± 1.44 ton ha^{-1}). By comparing both cultivars Cv. 1 gave maximum yield under unshaded conditions and lowest in Cv. 2 under fully shaded conditions (14.58 ± 0.59 ton ha^{-1}) [Tables 2 and 3]. The results of Cv. 1 under first two conditions were similar to the findings of Nabi *et al*.[18] when they applied 50 kg ha^{-1} of sulfate of potash (SOP) and muriate of potash (MOP) and under third condition with the application of 25 kg ha^{-1} of both MOP and SOP. The present results were lower than found by Abdelrazzag[17] by applying chicken, sheep manure, and inorganic fertilizers except from 20 ton ha^{-1} CM. Recorded results were much higher than observed by Gambo *et al*.[19] by introducing the farmyard manure, weed interference, and nitrogen fertilizers. Yields obtained from onion Cv. 2 under fully shaded conditions was similar to the results gathered by Syed *et al*.[20] by introducing NPK @ 120, 100, and 90 kg ha^{-1} respectively. Onion is highly sensitive to light and photoperiod, so it requires more light for its yield efficiency.[19] Keeping in view, these above parameters Cv. 1 under un-shaded and partially shaded conditions exhibited more production than other shade condition in spite of having equally distributed basal doses of fertilizers at the moment.

Effects of shaded trees of *Eugenia jambulana* on the horizontal diameter of bulbs of two onion cultivars

Shades, interactions (CXS), and blocks had significant ($P < 0.001$) effects on the bulb diameters, whereas cultivars did not significantly ($P > 0.001$) effect the bulb diameters [Table 3]. In Cv. 1, the highest diameter (7.83 ± 1.01 cm) of the bulb ranged from 7.4 to 8.1 cm found under unshaded conditions followed by partially shaded (5.66 ± 0.21 cm) ranged from 5.0 to 6.5 cm and fully shaded (5.033 ± 0.21) which ranged from 4.8 to 5.3 cm. Its trends consistently increased from unshaded to fully shaded conditions [Table 3]. The diameter of the bulb in Cv. 1 increased 58.5% under unshaded and 26.97% under partially shaded than grown under fully shaded conditions of *jumbolina* trees. Under partially and unshaded conditions, both cultivars revealed better results in case of bulb diameter, while under fully shaded conditions, Cv. 1 revealed better results. Main causes in reducing the diameters of onion bulbs might be the low availability of micro and micro nutrients and water to onion plants. Plants need ingredients such as carbon dioxide (CO_2), light, and chlorophyll for their photosynthetic activities for the sustainability of their life. Under the canopy of trees, onion plants could not carried out their photosynthetic processes freely. Bulb diameters found in present study were in close to the values (5–8 cm) recorded by Yassen and Khalid[16] by

Table 2: Differences in the weights of small, medium, and large sized bulbs of onion cultivars grown under fully shaded, partially shaded, and unshaded conditions

Cultivars	Conditions	Weight (tons ha^{-1}) small sized bulbs	Ranges	Weight (tons ha^{-1}) medium sized bulbs	Ranges	Weight (tons ha^{-1}) large sized bulbs	Ranges	Total yield (ton ha^{-1})
Cv. 1	Un-shaded	18.10±0.11[d]	17–18	8.25±0.55[c]	7–9	5.44±0.55[b,c]	4–6	31.79±1.20[a]
	Partially shaded	17.58±0.54[c,d]	12–17	10.58±0.41[c,d]	7–9	4.7±40.41[b]	5–8	31.20±1.44[a]
	Fully shaded	15.85±0.54[c]	12–15	5.55±033[b]	4–8	6.23±0.36[c]	4–7	26.36±0.14[b,c]
Cv. 2	Un-shaded	14.41±0.88[b]	10–14	8.44±0.65[b,c]	6–9	6.10±0.54[c]	6–4	28.70±1.45[c]
	Partially shaded	12.54±0.59[a,b]	11–14	9.47±0.22[c]	8–10	5.50±0.99[b,c]	3–8	24.11±0.58[b]
	Fully shaded	9.21±0.14[a]	9–10	3.54±0.11[a]	4–6	2.24±0.77[a]	1–3	14.58±0.59[d]

[a, b, c, d]Significant differences at P < 0.05, P < 0.01, and P < 0.001, respectively. NS = Not significant

Table 3: Differences in weights, diameters, circumferences of bulbs, and number of leaves plant^{-1} of onion cultivars grown under fully shaded, partially shaded, and unshaded conditions

Cultivars	Conditions	Weight of bulb (g)	Ranges	Diameter (cm) of bulb	Ranges	Circumference of bulb (cm)	Ranges	Number leaves plant^{-1}	Ranges
Cv. 1	Unshaded	162.62±9.10d***	147.94–178.54	7.83±0.77d***	7.4–8.1	24.20±2.44d***	22.8–25.00	15.14±0.25c,d***	13–15
	Partially shaded	70.28±3.11c**	57.42–94.02	5.66±0.21b**	5.0–6.5	17.96±3.10b**	16.5–19.8	13.42±0.58b,c**	12–13
	Fully shaded	40.47±3.20a*	31.06–50.54	5.033±0.21b*	4.8–5.3	14.53±1.01a*	13.00–15.5	9.25±0.58a*	9–12
Cv. 2	Unshaded	135.12±7.40c***	118.75–143.79	7.83±1.01c***	7.6–8.0	22.5±2.20c,d***	21.5–23.3	14.58±0.92b***	13.15
	Partially shaded	78.71±2.47b**	60.37–94.54	6.26±0.09d**	6.1–6.5	18.30±0.31a,b**	16.5–19.4	12.59±0.55b,c**	10–12
	Fully shaded	49.62±3.20a,b*	37.56–57.80	4.93±0.21a*	4.7–5.2	15.10±0.31a*	13.2–17.8	10.58±0.64a*	9–11

*, **, *** indicate significance levels at P<0.05, P<0.01, and P<0.001, respectively; NS = not significant

applying FYM and CM combinations except in Cv. 2 under fully shaded conditions (4.93 ± 0.21 cm) [Table 3]. Similar findings were also recorded in the experiments conducted by Abdou *et al*.[21] with various irrigation levels and potassium sources. Horizontal diameters of onion Cv. 2 under fully shaded conditions gave similar results found by Nasreen and Imamul[22] using different levels of sulfur (kg ha^{-1}) while all other exhibited greater diameters. Both cultivars under unshaded and partially shaded conditions gave higher yield that could be having more penetration of light through the canopy of *E. jambulana* trees. Onion requires cool and moist environment during early growth but latter on need drier conditions.[23] Rhizospheres of both the cultivars compete with root of *E. jambulana* for water, soil bound nutrients uptake, and plant growth promoting rhizobacteria under fully shaded environment. Some kinds of pests such as *Thrips tabaci* may also reduce their yield by feeding on the epidermal cells of plants. Reduction in productions under fully shaded conditions might be due to some onion pests which be present under the wet environment[23] and provided suitable situation to both cultivars under fully shaded conditions. More studies are required to explore the effects of pests on onion cultivars under all above said shade conditions.

Effects of shade of *Eugenia jambulana* trees on bulb circumference of *Allium cepa*

Bulb diameters varied significantly ($P < 0.001$) between two cultivars and blocks, whereas nonsignificant ($P > 0.001$) differences were observed for shade conditions and their interactions (V X S) [Table 2]. The Cv. 1 gave best results of bulb circumference (24.2 cm) ranged from 22.8 to 25.00 cm, (17.96 cm), from 16.5 to 19.8 cm, and (14.53 cm) from 13.0 to 15.5 cm under unshaded, partially shaded, and fully shaded conditions of *E. jambulana* trees, respectively. Both cultivars revealed better results under unshaded (22.5 ± cm) ranged from 21.5 to 23.3 cm followed by partially shaded (18.30 ± 0.31 cm) ranged from 16.5 to 19.4 cm, and fully shaded (15.10 ± 0.31 cm) ranged from 13.2 to 17.8 cm [Table 3]. It was concluded from the results that Cv. 1 gave better results of circumferences under partially and fully shaded conditions of *E. jambulana* trees. However, in both the cultivars, circumferences consistently increased from fully shaded to unshaded conditions. Similarly, increasing trends in circumferences of onion bulbs were recorded from fully shaded to unshaded conditions of *jambulana* trees. Significant variations ($P < 0.001$) were observed for blocks and cultivars, whereas nonsignificant differences ($P > 0.001$) were recorded for shade regimes and interactions between cultivars and shade conditions. The onion plants might freely be carried out their photosynthetic activities under the unshaded conditions and faced no any kind of competition with other plants. These plants acquired their food in kinds of macro and micro-nutrients and micro flora and fauna helped them for their better performance as compared to plants growing under partially and fully shaded regimes. Nutrient availability might be more to both cultivars under unshaded and partially shaded conditions as compared to under-fully-shaded conditions but competition between both cultivars for their requirements might be more under fully shaded conditions. Taking the advantages of more rhizosphere, rhizobacteria, root length, and root hairs, etc., the *E. jambulana* roots extracted more nutrients and let the onions roots scarce with them.

Effects of shade of *Eugenia jambulana* trees on the number of leaves of *Allium cepa*

Leaves per plants varied significantly in blocks ($P < 0.001$), cultivars ($P < 0.001$), and shade conditions ($P < 0.001$), whereas interactions (CXS) varied nonsignificantly ($P > 0.001$) [Table 2]. Maximum leaves per plant were observed in Cv. 1 under unshaded conditions (15.14 ± 0.25), while lowest under fully shaded conditions (9.25 ± 0.58) and their ranges were 13–15 and 9–12, respectively [Table 3]. Both cultivars gave the lowest leaves per plant under fully shaded conditions. The yield of both the cultivars increased with increase in number of leaves in unshaded conditions which might be owing to the increased phosynthetic rate due to free availability of CO_2 and direct sunlight. The yield in both the cultivars decreased under partially and completely shaded conditions. The results of onion Cv. 2 under-un-shaded conditions were in line with the findings of Nabi *et al*.[18] who obtained similar results when applied 50 and 75 kg ha^{-1} of MOP and SOP fertilizers. The Cv. 1 also showed same[18] trend under partially shaded conditions when applied 25 and 100 kg of MOP and SOP ha^{-1}. As SOP was applied at the beginning of experiment so it gave better results on the yield of both cultivars[24] also observed decrease in number and sizes of leaves per plant due to potassium deficiency. Leaves obtained per plant in both cultivars were greater than recorded by Syed *et al*.[20] who noted 6–7 per plant under the applications of different levels of FYM in Swat-I onion variety. Recent results were also similar to the findings of Abdou *et al*.[21] who recorded 11–13 leaves per plant by irrigation at 40%, 60%, and 80% available moisture levels and various levels of potassium. The number of leaves recorded in Cv. 2 under fully shaded conditions was similar to the findings of Ibrahim and Adesiyun[15] who obtained 10.13 and 11.60 leaves $plant^{-1}$ after 13 and 14 weeks of transplanting, respectively. Due to the lack of competitions between both producers under first two conditions gave better responses of leaves per plant. More leaves gave better yield of all three sizes of bulbs.

Comparison of firmness (lb $bulb^{-1}$) of bulbs in the cultivers of onion

Firmness of bulbs in blocks and under shade conditions did not differ significantly ($P > 0.001$). Similarly, both cultivars and their interactions (CXS) exhibited statistically significant variations ($P < 0.001$) [Table 4]. The Cv. 1 under unshaded (5.12 ± 0.66 lb $bulb^{-1}$) and partially shaded (8.25 ± 0.54 lb $bulb^{-1}$) gave greater firmness of bulbs than any other shade conditions. The Cv. 1 under fully shaded and unshaded while Cv. 2 under fully shaded conditions exhibited same firmnesses of bulbs. The lowest firmness (3.88 ± 0.14 lb $bulb^{-1}$) was recorded in Cv. 2 under partially shaded conditions [Table 5]. Random patterns of

Table 4: Firmness, moisture (%), weight loss (%), and sprouting of bulbs of onion cultivar grown under fully-shaded, partially shaded, and unshaded conditions

Cultivars	Conditions	Firmness (lbs)	Ranges	Moisture (%)	Ranges	Weight loss (%)	Ranges	Sprouting (%)	Ranges
Cv. 1	Unshaded	5.12±0.66^{b}	5–6	70±1.22^{a}	60–75	40±1.25^{a}	40–42	40±2.11^{d}	18–22
	Partially shaded	8.25±0.54^{c}	7–9	81±4.66^{c}	80–85	45±2.54^{b,c}	44–47	18±3.55^{a}	16–20
	Fully shaded	4.11±0.44^{a,b}	2–5	80±0.23^{b,c}	75–90	38±1.02^{a}	37–40	24±5.10^{a,b}	22–25
Cv. 2	Unshaded	4.00±0.01^{a,b}	3–5	75±4.47^{a,b}	70–80	50±0.25^{c}	48–55	19±1.02^{a}	24–26
	Partially shaded	3.88±0.14^{a}	2–6	74±1.34^{a}	74–78	48±5.14^{b,c}	47±51	26±1.00^{b}	32–37
	Fully shaded	4.88±0.44^{a,b}	4–5	78±0.88^{b}	76–85	40±3.54^{ab}	39–43	35±0.44^{c}	24–40

a, b, c, dSignificance level of indicate at P<0.05, P<0.01, P<0.001, and not significant (NS), respectively

Table 5: Analysis of variance for data of bulb weight, diameter, circumference, leaves/plant and firmness of onion cultivar grown under fully, partially, and un-shaded conditions

SOV	df	Mean sum of squares					
		Weight (g)	Diameter (cm)	Circumference (cm)	Leaves $plant^{-1}$	Firmness (Lbs)	Total yield (ton ha^{-1})
Blocks (B)	2	35428.20***	5841.21***	36582.58***	3214.99 (NS)	6534.54 (NS)	61534.154 (NS)
Cultivars (C)	1	2541.68***	256.25 (NS)	6987.08***	1254.55***	125.55***	1215.515***
Shades (S)	2	25448.25***	48731.14***	58792.58 (NS)	2547.44***	1423.87 (NS)	14123.187 (NS)
CXS	2	25.54 (NS)	25.50***	55.99 (NS)	47.66 (NS)	12.47***	121.147***
Error	10	3.25	2.69	7.10	8.54	2.22	2.212
Total	17	63,446.92	54,859.79	102,425.33	7025.52	8098.61	84094.64
C.V. (%)		12.44	6.55	44.55	9.41	12.56	10.00

***Significant differences at 0.001 levels. NS: Nonsignificant, CXS: Cultivars X shades, C.V = Cultivars, Cv. 1 = Cultivars 1, Cv. 2 = Cultivars 2

Table 6: Analysis of variance of data of bulb sizes, moisture (%), weight loss (%), and sprouting (%) of onion cultivars grown under fully, partially, and unshaded

SOV	df	Mean sum of squares					
		Bulb sizes (ton ha^{-1})			Moisture (%)	Weight loss (%)	Sprouting (%)
		Small	Medium	Large			
Blocks (B)	2	4582.65***	25461.66 (NS)	2547.21***	5472.36***	655.54	362.77**
Cultivars (C)	1	25905.0 (NS)	558.24 (NS)	25.25***	206.11***	25.21 (NS)	145.55***
Shades (S)	2	23666.41***	6587.36 (NS)	254.00***	487.52***	789.11 (NS)	14.54 (NS)
CXS	2	54.64***	89.05***	57.66 (NS)	12.47 (NS)	15.05 (NS)	14.11 (NS)
Error	10	12.07	7.85	15.44	5.49	4.11	2.88
Total	17	54,220.77	32,704.16	2899.56	6182.57	1489.02	539.85
C.V. (%)		9.54	6.25	13.87	5.10	8.47	55.33

**, ***Significant differences at 0.05, 0.01, and 0.001 levels, respectively. NS: Nonsignificant, CXS: Cultivars X shades, C.V = Cultivars, Cv. 1 = Cultivars 1, Cv. 2 = Cultivars 2

firmnesses were recorded under the three shaded conditions of *E. jambulana* in both cultivars. Firmness of bulbs in Cv. 1 under partially shaded conditions were in accordance with the results recorded by Nabi *et al*.[18] when they applied different levels of SOP and MOP to Swat-I, whereas all remaining shade conditions showed lesser compactness of their bulbs.

Comparison of moisture (%) contents in bulbs of the cultivars

Moisture levels (%) differed significantly ($P < 0.001$) in blocks and under shaded conditions. Their levels were also differing significantly ($P < 0.001$) in both cultivars, whereas interactions showed nonsignificant variations ($P > 0.001$) [Table 4]. Maximum moisture (%) was found under partially shaded (81.0 ± 4.66%) while the lowest under unshaded (70.0 ± 1.22%) conditions in Cv. 1. The partially and fully shaded conditions of Cv. 1 and unshaded and partially shaded conditions of onion Cv. 2 exhibited similar results [Table 5]. Better moistures contents were found in Cv. 1 than onion Cv. 2. The moisture levels in the present work were lower than results recorded by Syed *et al.* (2000) where they observed the effects of various levels of N and K on the moisture (%), dry weights (%), and total soluble solids (TSS%). Moisture % in Cv. 1 under partially (81.0 ± 4.66%) and fully shaded conditions (80.0 ± 0.23%) were parallel to the values recorded by Nabi *et al.*[18] by knowing the effects of 75 and 100 kg ha^{-1} of both SOP and MOP. Both the cultivars under remaining shade conditions showed lesser moisture contents and the Nabi *et al.*[18] also concluded that water contents were indirectly proportional to the dry matters in potatoes.

Weight loss (%) in the cultivers under shaded and un-shaded conditions

Significant variations ($P < 0.001$) were observed in weight losses (%) of bulbs grown in different blocks. Weight losses (%) did not show any significant differences ($P > 0.001$) between cultivars, shades, and in their interactions (VXC) among shade condition [Table 4]. Onion cultivar Cv. 2 gave maximum weight losses under all three conditions of shade. Maximum weight loss (50.0 ± 0.25%) was observed under unshaded condition in Cv. 2 cultivar while the lowest (38.0 ± 1.02%) under fullshaded conditions in Cv. 1 cultivar. More weight losses (%) were recorded under all three shaded conditions in Cv. 2 [Table 5]. The lowest weight losses (%) under fully shaded conditions were observed in Cv. 1 and were correlated with the findings of where they introduced 100 kg ha^{-1} of different sources of potassium and by the applications of sulfur (45 kg ha^{-1}) weight losses can be reduced in onion bulbs.[25]

Sprouting (%) in the cultivers under shaded and unshaded conditions

Sprouting (%) in blocks, grown under shaded conditions, varied significantly ($P < 0.001$) whereas on-significant differences ($P > 0.001$) were recorded in shaded conditions and interactions (C X S) [Table 4]. Maximum sprouting was recorded in Cv. 1 followed by Cv. 2 under fully and unshaded conditions, respectively. On overall basis, maximum sprouting (40.0 ± 2.11%) was observed under unshaded in Cv. 1 while lowest (19 ± 1.02%) under unshaded conditions in onion Cv. 2. Keeping in view the sprouting factor, it could be concluded that Cv. 2 proved better than Cv. 1 under unshaded conditions [Table 6] because being the lowest sprouting, it can be stored for a longer time as compare Cv. 1. The Cv. 1 under partially shaded conditions gave similar results as found by Nabi *et al*.[18] by introducing the different sources of potassium @ 50 kg ha^{-1}. Similarly, onion Cv. 2 under unshaded conditions revealed analogous findings with the applications of potassium sources @ 25 kg ha^{-1}. On over all bases, more weight losses were recorded in both cultivars under all the shaded conditions than found by Nabi *et al.*[18]

Conclusion

The study concludes that nutrient-depleted soils can be effectively utilized for cultivating onions with enhanced anticancer properties by fortifying them with nitrogen, sulfur, and potassium. Among the two onion cultivars tested, Cv. 1 demonstrated superior growth and yield, especially under unshaded conditions. This research highlights the potential of optimizing underutilized land for onion production, which not only improves yield but also enhances the medicinal value of onions, particularly their anticancer benefits. Proper nutrient management and environmental conditions are crucial for maximizing these outcomes, making this approach valuable for both agricultural productivity and public health.

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Conflicts of interest

There are no conflicts of interest.

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