



RESEARCH ARTICLE

ENHANCING ANTICANCER PROPERTIES OF ORGANOSULFUR COMPOUNDS IN *ALLIUM CEPA* THROUGH NITROGEN, SULFUR AND POTASSIUM FORTIFICATION IN BARREN LANDS

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ABSTRACT

To fortify nutrients depleting loam being waste under murkiness and use it for enhancing anticancer food rationing in human body two onion (*Allium cepa*) cultivars i.e. Cv.1 and Cv.2 (locally called "imported and 144" respectively) were experienced. Fertilizers were applied @ 50 kg of NH₄ (SO₄)₂ and 25 kg of MOP (muriate of potash) per acre⁻¹ with first irrigation. Growth parameters were recorded under un-shaded, partially and fully-shaded canopies of *Eugenia* trees. 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, maximum yield of bulbs (small and medium sized) were 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) 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. The response of both the cultivars were beneficially under such environment, however Cv.1 was better. It was inferred from the result that onion which is the excellent source of moderate level of anticancer diet can be obtained on these depleted soil by adding essential macronutrients.

KEYWORDS

Macronutrient Enrichment, *Allium cepa* Cultivars, Nutrient Depleted Soils, Cancer Prevention

1. INTRODUCTION

Managing essential chemical nutrients in nutrients depleting and dissipating loams have a vital role to play in enhancing food medicinal values, especially in Pakistan which has 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 (Ahmed, 2008) 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 (Teshika, 2019). It produces a chemical compound (mostly cistein 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 (Khan et al., 2021). In addition, onion is among the food plants to which moderate level of anticancer activities is associated with (Michael, 2006). Studies have shown 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 is extensive and some studies also

carried out to observe the effects of various fertilizers on the yield of onion and quality of its bulbs but limited on waste, shaded and nutrient depleted soils (Tiwari et al., 2017; Jilani et al., 2004; Khan et al., 2008). In view of this, the present study was initiated on this nutrients deleting soil to augment rationing of *Allium cepa* to reduce risk of cancer in our society.

The bioactive qualities of organosulfur compounds found in *Allium* species, such as *Allium cepa* (onion), have demonstrated substantial potential as anticancer drugs (Velraj, 2024). 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 (Iwar et al., 2024). It is essential to prevent cancer and other diseases since these substances contain anti-inflammatory and antioxidant properties (Mirzoeva et al., 2024). 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 (Mirzoeva et al., 2024).

2. MATERIALS AND METHODS

The experimental studies were conducted at NIAB Campus area (1 acre) under the *E. jambulana* trees along the road from main NIAB gate to 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

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satisfactory for experimentation. Preliminary two cultivars of onion viz., Cv.1 and Cv.2 were grown with rows and plant to plant distances of 12 and six inches 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 eight days. After the transfer of seedlings one bag of $(\text{NH}_4)_2\text{SO}_4$ (50 kg acre⁻¹) and half bag of muriate of potash (25kg acre⁻¹) were applied with first irrigation. The experimental area was situated between latitude 31o 24o N, longitude 73o 1o E and height above sea level 184 meters. Soil samples were analyzed by using pH meter (8520, Hanna) and EC meter (LF 538, WTW, Germany).

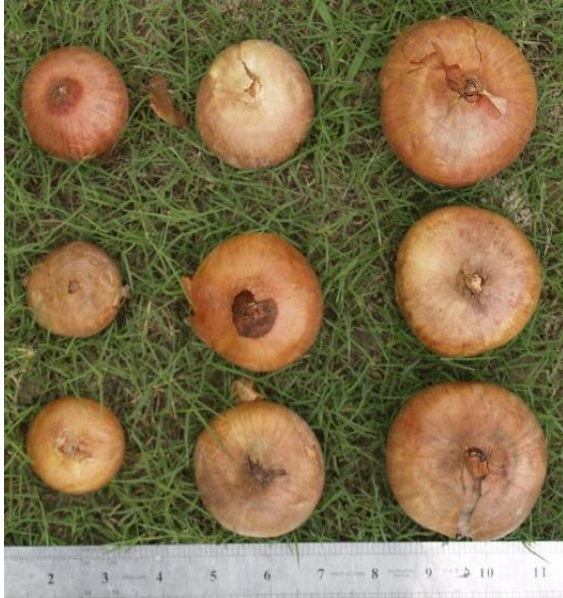


Figure 1: Transverse sections of onion cultivars (a) Cv.1 (b) Cv.2 showing horizontal diameters of large, medium and small sized bulbs, grown under un-shaded, partially and fully-shaded.

Experimental soil was characterized with pHs 7.9-8.0, ECe 2.1 to 2.4 dS m⁻¹, organic matter (O.M.) 0.87%, total nitrogen (T.N.) 0.065%, soil NO₃-N 7ppm, available phosphorus 7-8ppm, available potassium 270-276ppm and water holding capacity 29% with sandy clay loam texture. The micronutrients contents were analyzed on Atomic Absorption Spectrophotometer (Table.1). During study period average day temperature ranged from 33-41°C, night 25-30°C, relative humidity range from 40-50%, wind speed 1.22-1.50 m S⁻¹ and mean air pressure 1300MPa. Randomize complete block design (RCBD) with split plots was established for this purpose. Site was divided into four blocks with two cultivars and three *E. jambulana* shade regimes viz, 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 verniercaliper and the circumferences with the help of inches' tape. Compactness was calculated by using penetrometer (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 hours and intermittently recorded their weights until they became constant. After harvesting plant samples were put in refrigerators in order to avoid the moisture losses. The data obtained during study period were analyzed by statistically analysis system (Guide, 1995). Significant differences were analyzed at 0.05 levels. Differences among means were ranked using Duncan's New Multiple Range Tests (Duncan, 1955; Steel and Torri,1980).

Table 1: Atomic Absorption Spectrophotometric analysis of soils for Cr, Pb, Ni and Cd concentration

Micronutrients	Range	Average concentration
Cr	14.6 to 15.5 $\mu\text{g g}^{-1}$	15.05 $\mu\text{g g}^{-1}$
Pb	11.9 to 12 $\mu\text{g g}^{-1}$	11.95 $\mu\text{g g}^{-1}$
Ni	17.2 to 18.2 $\mu\text{g g}^{-1}$	17.7 $\mu\text{g g}^{-1}$
Cd	0.2 to 0.6 $\mu\text{g g}^{-1}$	0.4 $\mu\text{g g}^{-1}$

3. RESULTS AND DISCUSSION

3.1 Shade Effects Of *E. 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 147.94-178.54 g) under the un-shaded conditions followed by partially shaded 70.28 g (ranged from 57.42-94.02 g) and shaded 40.47 g (ranged from 31.06-50.64 g). Similarly, in Cv.2 weights of bulbs gradually increased from un-shaded (135.12 g, ranged from 118.75-143.79 g), partially shaded (78.71±2.47 g, ranged from 60.37-94.54 g) and under fully-shaded (49.62±3.20 g) conditions (ranged from 37.56-57.80 g). Both the cultivars of *A. cepa* showed the highest yield under un-shaded while the lowest under fully-shaded conditions of *E. jambulana* trees. The bulb weight increased from 305% in un-shaded and 75% for partially than fully shaded conditions. Similar in Cv.1the weight of onion bulb increased 175% under un-shaded 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 un-shaded condition Cv.1 cultivar gave better results. Bulbs under shaded conditions exhibited low weight 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 small plants of onion. Environmental conditions like, sunlight, humidity, 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 un-shaded condition (162.62±9.10 g-1) followed by onion Cv.2 under un-shaded (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 un-shaded followed by Cv.2 (118.75-143.79) under un-shaded conditions. Present results were similar to the findings of Ibrahim and 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 un-shaded conditions was higher than values found with application of various combinations of FYM and chicken manure (CM). Bulb weights in Cv.2 under un-shaded conditions were similar to the weights of smallest bulbs recorded by with the introduction of 80 ton ha-1 chicken manure and 80 ton ha-1 sheep manure (Abdelrazzag, 2002).

3.2 Total Yield Of Two Cultivars Under Three Shaded Conditions Of *E. 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 un-shaded (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 un-shaded conditions and lowest in Cv.2 under fully-shaded conditions (14.58±0.59 ton ha-1) (Table 2). The results of Cv.1 under first two conditions were similar to the findings of when they applied 50 kg ha-1 of SOP and MOP and under third condition with the application of 25 kg ha-1 of both MOP and SOP (Nabi et al., 2010). Present results were lower than found applying chicken, sheep manure and inorganic fertilizers except from 20 ton ha-1 chicken manure by (Abdelrazzag, 2002). Recorded results were much higher than observed introducing the farmyard manure, weed interference and nitrogen fertilizers (Gambo et al., 2008). Yields obtained from onion Cv.2 under fully-shaded conditions was similar to the results gathered 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 (Abdelrazzag, 2002; Syed et al., 2000). 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.

3.3 Effects Of Shaded Trees Of *E. 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 5). In Cv.1 the highest diameter (7.83±1.01 cm) of bulb ranged from 7.4-8.1 cm found under un-shaded conditions followed by partially shaded (5.66±0.21 cm) ranged from 5.0-6.5 cm and fully shaded (5.033±0.21) which ranged from 4.8-5.3 cm. Its trends consistently increased from un-shaded to fully shaded conditions (Table 2). Diameter of bulb in Cv.1 increased 58.5% under un-shaded and 26.97% under partially-shaded than grown under fully-shaded conditions of *jumbolina* trees. Under partially and un-shaded 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 like CO₂, 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 applying FYM and CM combinations except in Cv.2 under fully-shaded conditions (4.93±0.21 cm) (Table 2) (Yassen and Khalid, 2009). Similar findings were also recorded in the experiments conducted with various irrigation levels and potassium sources by (Abdou et al., 2009). Horizontal diameters of onion Cv.2 under fully-shaded conditions gave similar results found using different levels of sulphur (kg ha-1) while all other exhibited greater diameters (Nasreen and IMAMUL, 2003). Both cultivars under un-shaded 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 (Purseglove, 1992). Rhizospheres of both the cultivars compete with root of *E. jambulana* for water, soil bound nutrients uptake and plant growth promoting rhizobacteria (PGPR) under fully-shaded environment. Some kinds of pests like thrips tabaci may also reduce their yield by feeding on epidermal cells of plants. Reduction in productions under fully-shaded conditions might be due to some onion pests which be present under wet environment and provided suitable situation to both cultivars under fully shaded conditions (Purseglove, 1992). More studies are required to explore the effects of pests on onion cultivars under all above said shade conditions.

Table 2: Differences in weights, diameters, circumferences of bulbs and number of leaves plant⁻¹ of onion cultivars grown under fully-shaded, partially-shaded and un-shaded conditions.

Cultivars	Conditions	Weight of bulb (g)	Ranges	Diameter (cm) of bulb	Ranges	Circumference of bulb (cm)	Ranges	No. leaves plant ⁻¹	Ranges
Cv.1	Un-shaded	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±0.25cd	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±0.58bc	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	Un-shaded	135.12±7.40c	118.75-143.79	7.83±1.01c	7.6-8.0	22.5±2.20cd	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±0.31ab	16.5-19.4	12.59±0.55bc	10-12
	Fully shaded	49.62±3.20ab	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

3.4 Effects Of Shade Of *E. Jambulana* Trees On Bulb Circumference Of *A. cepa*

Bulb diameters varied significantly ($p<0.001$) between two cultivars and blocks whereas non-significant ($P>0.001$) differences were observed for shade conditions and their interactions (V X S) (Table 5). The Cv.1 gave best results of bulb circumference (24.2 cm) ranged from 22.8-25.00 cm, (17.96 cm), from 16.5-19.8 cm and (14.53 cm) from 13.0-15.5 cm under un-shaded, partially shaded and fully shaded conditions of *E. jambulana* trees respectively. Both cultivars revealed better results under un-shaded (22.5± cm) ranged from 21.5-23.3 cm followed by partially shaded (18.30±0.31 cm) ranged from 16.5-19.4 cm and fully shaded (15.10±0.31 cm) ranged from 13.2-17.8 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 un-shaded conditions. Similarly increasing trends in circumferences of onion bulbs were recorded from fully shaded to un-shaded conditions of *jambulana* trees. Significant variations ($p<0.001$) were observed for blocks and cultivars whereas non-significant 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 un-shaded 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 un-shaded 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.

Table 3. Analysis of variance (ANOVA) 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}
Cultivars X Shades (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	63446.92	54859.79	102425.33	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, non-significant

3.5 Effects Of Shade Of *E. Jambulana* Trees On Number Of Leaves Of *A. 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 non-significantly ($P > 0.001$) (Table 5). Maximum leaves per plant were observed in Cv.1 under un-shaded 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 2). 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 un-shaded conditions which might be owing to the increased photosynthetic rate due to free availability of carbon-dioxide (CO_2) and direct sun light. 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 who obtained similar results when applied 50 and 75 kg ha⁻¹ of MOP and SOP fertilizers (Nabi et al., 2010). The Cv.1 also showed same trend under partially-shaded conditions when applied 25 and 100 kg of MOP and SOP ha⁻¹ (Nabi et al., 2010). As SOP was applied at the beginning of experiment so it gave better results on the yield of both cultivars also observed decrease in number and sizes of leaves per plant due to Potassium deficiency (Pettigrew, 2008). Leaves obtained per plant in both cultivars were greater than recorded who noted six to seven per plant under applications of different levels of farm yard manure (FYM) in Swat-I onion variety (Syed et al., 2000). Recent results were also similar to the findings of who recorded 11-13 leaves per plant by irrigation at 40, 60,

80% available moisture levels (ASM) and various levels of potassium (Abdou et al., 2009). Number of leaves recorded in Cv.2 under fully-shaded conditions was similar to the findings of who obtained 10.13 and 11.60 leaves plant⁻¹ after 13 and 14 weeks of transplanting respectively (Ibrahim, and Adesiyun, 2010). 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.

3.6 Comparison Of Firmness (Lb Bulb-1) Of Bulbs In The Cultivars 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 6). The Cv.1 under un-shaded (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 un-shaded 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 4). Random patterns of firmnesses were recorded under 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 when they applied different levels of SOP and MOP to Swat-I whereas all remaining shade conditions showed lesser compactness of their bulbs (Nabi et al., 2010)

Table 4. Analysis of variance (ANOVA) of data of bulb sizes, moisture (%), weight loss (%) and sprouting (%) of onion cultivars grown under fully, partially and un-shaded

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}
Cultivars X Shades (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	54220.77	32704.16	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, non-significant

3.7 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 non-significant variations ($p > 0.001$) (Table 5). Maximum moisture (%) was found under partially-shaded ($81.0 \pm 4.66\%$) while the lowest under un-shaded ($70.0 \pm 1.22\%$) conditions in Cv.1. The partially and fully-shaded conditions of Cv.1 and un-shaded and partially-shaded conditions of onion Cv.2 exhibited similar results (Table 3). Better moistures contents were found in Cv.1 than onion

Cv.2. The moisture levels in present work were lower than results recorded by Syed et al. (2002) 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 ($81.0 \pm 4.66\%$) and fully-shaded conditions ($80.0 \pm 0.23\%$) were parallel to the values recorded knowing the effects of 75 and 100 kg ha⁻¹ of both SOP and MOP (Nabi et al., 2010). Both the cultivars under remaining shade conditions showed lesser moisture contents and the also concluded that water contents were indirectly proportional to the dry matters in potatoes (Nabi et al., 2010).

Table 5: Differences in weights of small, medium and large sized bulbs of onion cultivars grown under fully-shaded, partially-shaded and un-shaded 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±0.11d	17-18	8.25±0.55c	7-9	5.44±0.55bc	4-6	31.79±1.20a
	Partially shaded	17.58±0.54cd	12-17	10.58±0.41cd	7-9	4.7±0.41b	5-8	31.20±1.44a
	Fully shaded	15.85±0.54c	12-15	5.55±0.33b	4-8	6.23±0.36c	4-7	26.36±0.14bc
Cv.2	Un-shaded	14.41±0.88b	10-14	8.44±0.65bc	6-9	6.10±0.54c	6-4	28.70±1.45c
	Partially shaded	12.54±0.59ab	11-14	9.47±0.22c	8-10	5.50±0.99bc	3-8	24.11±0.58b
	Fully shaded	9.21±0.14a	9-10	3.54±0.11a	4-6	2.24±0.77a	1-3	14.58±0.59d

3.8 Weight Loss (%) In The Cultivars 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 6). Onion cultivar Cv.2 gave maximum weight losses under all three conditions of shade. Maximum weight loss (50.0±0.25%) was observed under un-shaded condition in Cv.2 cultivar while the lowest (38.0±1.02%) under full-shaded conditions in Cv.1 cultivar. More weight losses (%) were recorded under all three shaded conditions in Cv.2 (Table 3). The Lowest weight losses (%) under fully-shaded conditions were observed in Cv.1 and were correlated with findings of where they introduced 100 kg ha⁻¹ of different sources of potassium and by the applications of sulphur (45 kg ha⁻¹) weight losses can be reduced in onion bulbs (Ullah et al., 2008).

3.9 Sprouting (%) In The Cultivars Under Shaded And Un-Shaded Conditions

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 6). Maximum sprouting was recorded in Cv.1 followed by Cv.2 under fully and un-shaded conditions, respectively. On overall basis maximum sprouting (40.0±2.11%) was observed under un-shaded in Cv.1 while lowest (19±1.02%) under un-shaded conditions in onion Cv.2. Keeping in view the sprouting factor it could be concluded that Cv.2 proved better than Cv.1 under un-shaded 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 (Nabi et al., 2010) introducing the different sources of potassium @ 50 kg ha⁻¹. Similarly, onion Cv.2 under un-shaded 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 (Nabi et al., 2010).

Table 6. Firmness, moisture (%), weight loss (%) and sprouting of bulbs of onion cultivar grown under fully-shaded, partially-shaded and un-shaded conditions

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

4. 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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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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