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Short Note

Evaluation of lettuce genotypes for yield and quality under protected conditions of North-western Himalayas

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Abstract

Lettuce is a popular salad vegetable in European countries. In India its demand is also increasing. It is not possible to grow salad vegetables under open environmental conditions due to vagaries of weather. The state government in Himachal Pradesh (India) is promoting polyhouse cultivation in a very big way. But the lack of suitable cultivars under polyhouse conditions is the biggest challenge to the growers of the hilly state. Therefore, in the present study seven genotypes of lettuce *viz*. Red Butter Head (G_1), Ice-berg (G_2), Revolution (G_3)**,** Dublin (G_4), Garishma (G_5), Bergamo (G_6) and Green Romaine (G_7) were evaluated in a 36 x 6 m modified naturally ventilated polyhouse having fan pad system. Maximum gross weight (826.6 g/plant) was recorded in G_2 which was statistically at par with G_4 (791.6 g/plant). Minimum gross weight per plant was found in G_7 (18836 g). Maximum net weight/plant was recorded in G_7 (631.3 g) which was statistically at par with G_2 (578.3 g), G_4 (583.6 g), G_5 (458.6 g) and G_6 (480.3 g). Lettuce genotypes also varied in quality parameters *viz*. chlorophyll b and total chlorophyll, starch, reducing, non-reducing and total sugars and sodium content.

Key words: Lettuce, polyhouse, protected cultivation**,** salad vegetable

Lettuce (*Lactuca sativa* L), a member of family Asteracae is the most important salad crop of European countries. It also occupies an important position in tropical and subtropical countries. In temperate countries, it is mostly grown under glass and plastic structures (Santos Filho *et al*. 2009; Carlo Fallovo et al 2009). In India, it is a minor commercial crop grown on a small scale in home gardens. It is an important polymorphic plant particularly with respect to foliage characteristics. It grows to a height of 10 to 20 cm with spread of 15 to 30 cm. Lettuce is a cool season crop. The optimum mean temperature range for excellent growth and good quality of lettuce is 15–25 ^{0}C. The temperature above 25 ^{0}C accelerates seed stalk and reduces the quality of leaves. It prefers light loam or sandy loam well drained fertile soils with pH 6-8. Lettuce is a rich source of chlorophyll, water, ascorbic acid, ash, starch, sugars and sodium which are the essential components of balanced diet.

Chlorophyll is a green pigment found in most plants is one of the oldest and most widely consumed pigments in our diet. As it has been in the human diet forever, it can be considered one of the most safe food components. Although all varieties of lettuce have low calories, each variety has different nutrient content. Romaine lettuce is the most nutrient-dense of all the lettuce varieties and is an excellent source of vitamins A, B1, B2, and C, folic acid, manganese and chromium, while Iceberg lettuce variety provides a good source of choline. The outer leaves may contain fifty times more nutrients than the stem. Lettuce is a good source of chlorophyll and vitamin K, good for dieters because it is very low in calories. Lettuce is a good source of iron which is the most active element in the body. Therefore, it must be replenished frequently to meet any sudden demand of the body such as the rapid formation of red blood corpuscles in heavy loss of blood.

Magnesium content has exceptional vitalizing powers especially in the muscular tissues, the brain and the nerves. Lettuce may also help to treat acid indigestion, anemia, arthritis, catarrh, circulatory problems, colitis, constipation, cough, diabetes, gastritis, gout, insomnia, irritable bowel, obesity, sexual addiction, stress, tuberculosis, ulcers and urinary tract diseases.

In recent time people are becoming health conscious and demand for salad in food is increasing. In India protected cultivation is an emerging field and standardized package for lettuce production as well as suitable varieties/ hybrids under protected conditions is scarce. In Himachal Pradesh too, polyhouse technology is becoming popular with the efforts of the state government, where 80% subsidy for construction of polyhouses is being provided by the government under "*Pandit Deen Dyal Updhyay Kisan Bagwan Samridhi Yojna*" (Pandit Deen Dyal Farmers-Horticulturists Progress Plan). Lettuce can be used as a gap crop in the polyhouses to incur more income. The lettuce is high-value, thermo sensitive vegetable crop which can be grown successfully under polyhouse conditions. However, there is no scientific information available in India on lettuce cultivation under polyhouses. The work on its quality estimation has also been limited. Therefore, the present study was conducted to evaluate different hybrids for yield and quality traits of lettuce under protected conditions.

The present investigation was undertaken at Palampur (32^0 6' N latitude, $76^0$3' E longitudes and 1290.8 m altitude) during 2009. Severe winters and mild summers with high rainfall characterize the place. Agro climatically, the location represents the mid-hill zone of Himachal Pradesh. It is characterized by humid sub-temperate climate with high rainfall (2500 mm), of which 80% is received during June to September. During October, there is no crop inside the polyhouse, therefore, to utilize the lean period, 7 genotypes *viz*. G_1 - Red Butter Head, G_2 - Green Ice-berg, G_3 - Revolution**,** G_4 - Dublin, G_5 - Garishma, G_6 - Bergamo and G_7 - Green Romaine were undertaken and planted in Randomized Block Design with 3 replications in a 36 x 6 m modified naturally ventilated polyhouse. The crop was grown on 20 cm raised bed having 70 cm width. Vermicompost (at 5 t/ha) and chemical fertilizers (60: 40: 40 kg N, P_2O_5 and K_2O/ha) were applied in pits before transplanting. Plants of each genotype were planted at inter row distance of 45 cm and intra plant distance of 30 cm. The intercultural operations i.e. hoeing and weeding were carried out in accordance with recommended package of practices to ensure a healthy crop growth and development. The observations were recorded on various yield contributing and quality traits in 5 randomly selected plants in each entry. The parameters recorded on growth and yield were: plant frame (cm^2), stem length (cm), stem diameter (cm), gross weight (g), net weight (g), polar diameter (cm), equatorial diameter (cm) and quality traits such as uniformity, heading (%), head shape, leaf colour, leaf texture, leaf shape, taste, colour of core, firmness, ascorbic acid content (mg/100 g)**,** chlorophyll 'a'/g tissue , chlorophyll 'b'/g tissue, total chlorophyll/g tissue total, moisture (%), ash (%), starch (%), total sugars, reducing sugars (%), non-reducing sugars and Na (g/100 g) following standard procedures (AOAC 1990; Hodege and Hofreiter 1962; Jayraman 1981; Miller 1972; Subbarao et al. 2003). Total chlorophyll was estimated spectrophotometrically by the method of Jayraman (1981).

Extraction of total chlorophyll was carried out in cleaned pestle and mortar by grinding fresh samples (0.2 g) with 80% acetone. The extracts were centrifuged at 4,000 rpm for 15 min and then chlorophylls were repeatedly extracted out with 20 ml (5-5 ml repeatedly, 4 times) 80% acetone until residues became colourless. Finally, the volume was made up to 20 ml with 80% acetone and absorbance was measured at 663, 645 and 480 nm with the help of ELICO (India) SL-159 UV-VIS Spectrophotometer. For the estimation of ascorbic acid (AOAC, 1990), 100 g of fresh lettuce samples were grounded with 100 ml of 2% oxalic acid as extraction medium in order to get slurry. The weight of slurry was recorded and 20 g of this slurry was taken in a beaker and its volume was made up to 100 ml with 1% oxalic acid. The content of the beaker was filtered properly through Whatman Filter paper No. 1. Charcoal treatment was given if any colour remained due to pigments. 5 ml of this filtrate was pipetted out and titrated against a dye solution (2,6 dichlorophenol indophenol) prepared by taking 52 mg of dye in 200 ml volumetric flask adding 100 ml of hot distilled water. The volume was then made to 200 ml with distilled water. After cooling 42 mg of $NaHCO_3$ was added and dissolved properly. At the same time 100 mg of ascorbic acid was dissolved in 500 ml of 1% oxalic acid solution was used as standard (always prepared fresh). Moisture content in the lettuce was determined by following the oven drying method. Estimation of starch was done by anathrone reagent method by using various reagents such as: 0.1 to 0.5 g of the sample homogenized in hot 80% ethanol to remove sugars, centrifuged and retained the residue, washed the residue repeatedly with hot ethanol (80%) till the washings did not give colour with anthrone reagent and dried the residue over a water bath. To the residue 5.0 ml of water and 6.5 ml of

52% perchloric acid were added. Extracted at 0 ^{0}C for 20 minute with centrifuge and sage the supernatant; repeated the extraction using fresh perchloric acid. Centrifuged and poured the supernatants and made up to 10 0ml. 0.1 or 0.2 ml of the supernatant was piped out and made up the volume to 1 ml with water. Prepared the standards by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and made up the volume to 1 ml in each tube with water. Added 4 ml of anthrone reagent to each tube and heated for eight minutes in a boiling water bath. Cooled rapidly and read the intensity of green to dark green colour at 630 nm. The glucose content in the sample was noted by using the standard graph and multiplied with the value by a factor 0.9 to arrive at the starch content. The estimation of reducing sugar was carried out by dinitrosalicylic acid method**.** Dissolved by stirring 1 g dinitrosalicylic acid, 200 mg crystalline phenol and 50 mg sodium sulphite in 100 ml 1% NaOH and stored at 4^0C. Since the reagent deteriorates due to sodium sulphite, it may be added at the time of use if long storage is required. Followed steps 1 to 3 as in Nelson -Simonyi's method to extract the reducing sugars from the test material. Piped out 0.5 to 3 ml of the extract in test tubes and equalized the volume to 3 ml with water in all the tubes. Added 3 ml of DNS reagent and heated the contents in a boiling water bath for 5 min. When the contents of the tubes were still warm, 1 ml of 40% Rochelle salt solution was added. Cooled and read the intensity of dark red colour at 510 nm. Run a series of standards using glucose (0 to 500 mg) and plot a graph. Calculated the amount of reducing sugars in the sample, using the standard graph. The concentration of non reducing sugar was determined as the differences in the concentration of total sugars and reducing sugar.

Mineral content in lettuce genotypes was estimated with standard procedure by using 3 g of dried and finely ground sample in 100 ml Kjeldahl flask. 25 ml of mixture of concentrated HNO_3, concentrated $HClO_3$ and concentrated H_2SO_4 was added in ratio of 3:2:1 and shaked well so that no dry lumps were left behind. A clean acid washed glass bead was dropped into flask to avoid bumping during digestion. This flask containing sample was allowed to stand for 3-4 hours in a fume cupboard. Then this was heated on digestion heater and was watched out for foaming during the first hour. In case of excessive foaming which tends to overflow, the bulb of flask was immersed in cold water till the digestion was completed. Then it was allowed to cool and the digested samples were filtered through Whatman filter paper No. 40 into a 100 ml volumetric flask. It was made sure that contents of digestion flask were quantitatively transferred by rinsing the flask 3-4 times with deionized water. The silica residue was washed on filter paper with dilute HCl (1: 19) in order to wash down salts completely. The volume of collected filtrate was made 100 ml. This mineral solution was transferred in pre acid washed polythene bottles and stored in a cool place till use. Mineral sodium was analyzed in 100 ml of ash solution. Sodium and potassium were estimated by Flame Photometry using Systronics-129 Flame Photometer. Dilutions, where required were made with double distilled water and dilution factor were incorporated in final calculations.

The data on yield contributing characters and yield are summarized in Table 1.

Table 1. Effect of genotypes on **y**ield contributing characters and yield of lettuce

Genotypes	Plant frame (cm^2)	Stem length (cm)	Stem diameter (cm)	Gross weight (g/plant)	Net weight (g/plant)	Polar diameter (cm)	Equatorial diameter (cm)
Red Butter Head (G_1)	535.0	4.3	2.5	373.3	294.0	13.7	10.8
Ice-berg (G_2)	1111.7	3.7	2.6	826.7	578.3	12.3	11.2
Revolution (G_3)	794.0	3.3	1.8	188.7	206.7	20.3	12.3
Dublin (G_4)	845.0	3.9	2.3	791.7	583.7	12.0	10.7
Garisma (G_5)	970.3	3.5	2.5	682.0	458.7	12.2	11.7
Bergamo (G_6)	874.3	3.5	2.3	509.7	480.3	17.7	18.3
Green Romaine (G_7)	1137.0	3.7	2.5	656.0	631.3	30.0	20.7
LSD (P=0.05)	NS	NS	NS	152.9	175.7	4.5	5.9
CV (%)	25.9	23.4	16.5	14.8	21.1	14.7	24.2

Plant frame, stem length and stem diameter though shown wide variation under genotypes but were not affected significantly as having greater CV values. However, gross and net green weight/plant varied significantly due to genotypes. Maximum gross weight (826.6 g/plant) was recorded under G_2 (Green Ice-berg) which was statistically at par with G_4 (Dublin) (791.6 g/plant). Minimum gross weight per plant was found in G_3 (Revolution) (188.6 g/plant). Maximum values of net weight were recorded in G_7 (Green Romaine) (631.3 g/plant) which was statistically at par with G_2 (Green Ice-berg) (578.3 g/plant), G_4 (Dublin) (583.6 g/plant), G_5 (Garishma) (458.6 g/plant) and G_6 (Bergamo) (480.3 g/plant). Polar and equatorial diameter were also significantly varied due to genotypes. Highest polar diameter (30 cm) was recorded in G_7 (Green Romaine) whereas, it was lowest in G_5 (Garishma) (12.16 cm). Similarly equatorial diameter was maximum (20.6 cm) in G_7 (Green Romaine) and lowest in G_4 (Dublin) (10.6 cm) (Table 1).

Various morphological quality parameters studied are shown in Table 2. All the genotypes were uniform in growth. There were three types of genotypes under investigation *viz*; heading, semi heading and leafy. Heading percentage was uniform and its shape was round in all heading genotypes. The leaf colour varied and all the genotypes have different leaf colour. G_1 (Red Butter Head) was reddish tinged green, G_2 (Green Ice-berg) having petiole white, G_3 (Revolution) purple, G_4 (Dublin) and G_5 (Garishma) light green, G_6 (bergamo) yellowish green and G_7 (Green Romaine) was dark green. Colour of the core was also different in all the genotypes. Genotype G_1 (Red Butter Head) had yellow core, G_2 (Green Ice-berg) with yellow green, G_3 (Revolution) having purple with greenish tinge, G_4 (Dublin) white yellowish and G_5 (Garishma), G_6 (Bergamo) and G_7 (Green romaine) had white green core (Table 2). Leaf texture was smooth in G_1 (Red Butter Head) and G_4 (Dublin), having serrated leaves in G_2 (Green Ice-berg) and G_3 (Revolution), toothed margin leaves in G_5 (Garishma); G_6 (Bergamo) had fan type leaves and G_7 (Green Romaine) was non heading open type. All the genotypes were sweet in taste except G_6 (Bergamo) and G_7 (Green Romaine) which were slightly bitter.

Among the quality characteristics, chlorophyll 'a'/g tissue, ascorbic acid and Ash % did not exhibit significant differences due to genotypes under polyhouse conditions (Table 3). Highest chlorophyll 'b'/g tissue was estimated in G_3 (Revolution) (0.237), followed by G_6 (Bergamo) (0.187), G_7 (Green Romaine) (0.170) and G_1 (Red Butter Head) (0.159) which were statistically at par. Its lowest

Table 2: Morphological quality parameters of the various genotypes

Genotype	Uniformity	Heading (%)	Head shape	Leaf color	Leaf texture	Leaf shape	Taste	Color of core	Firmness
Red Butter Head (G_1)	Uniform	100	R	Reddish tinged green	Smooth	Oblong	Sweet	Yellow	Slightly loose
Ice-berg (G_2)	Uniform	100	R	Petiole white	Serrated leaves	Fan type	Sweet	Yellow green	Compact
Revolution (G_3)	Uniform	Leafy	-	Purple	Serrated leaves	Fan type	Sweet	Purple with greenish tinge	Loose
Dublin (G_4)	Uniform	100	R	Light Green	Smooth	Fan type	Sweet	White yellow-ish	Compact
Garisma (G_5)	Uniform	100	R	Light Green	Toothed margins of leaves	Round	Sweet	White Green	Compact
Bergamo (G_6)	Uniform	Leafy	-	Yellowish green	Puckered leaves smooth	Fan type	Slightly bitter	White Green	Loose
Green Romaine (G_7)	Uniform	Leafy	-	Dark Green	Smooth	Non heading open	Slightly bitter	White Green	Loose

Table 3. Genotype effect on quality in lettuce

Genotypes	Chloro-phyll 'a'/ g tissue	Chloro-phyll 'b'/ g tissue	Total chloro-phyll / g tissue	Mois-ture %	Ascorbic acid mg/100g	Ash %	Starch %	Reducing sugar %	Non reduc-ing sugar %	Total sugar %	Na mg/100g
Red Butter Head (G_1)	0.231	0.159	0.390	95.5	5.8	7.37	15.5	1.78	3.40	5.09	32.3
Ice-berg (G_2)	0.030	0.047	0.079	97.6	7.7	6.17	14.5	1.58	2.38	3.96	31.6
Revolution (G_3)	0.255	0.237	0.491	94.9	7.5	11.2	3.5	0.51	0.67	1.18	33.6
Dublin (G_4)	0.191	0.057	0.098	97.0	7.6	5.0	14.0	1.09	2.82	3.58	32.7
Garisma (G_5)	0.082	0.090	0.172	96.7	9.4	8.2	19.4	2.04	2.41	4.45	32.3
Bergamo (G_6)	0.148	0.187	0.302	94.9	6.7	10.2	5.8	1.67	3.17	4.84	34.4
Green Romaine (G_7)	0.319	0.170	0.488	93.2	8.8	7.8	15.9	1.19	2.81	3.99	32.2
LSD (P=0.05)	NS	0.117	0.139	2.1	NS	NS	1.8	0.24	0.68	0.56	1.4
CV (%)	59.3	48.2	26.8	1.2	20.9	30.2	7.7	9.4	15.1	8.1	2.4

value (0.057) was recorded in G_4 (Dublin). Total chlorophyll was highest (0.491/g tissue) in G_3 (Revolution) which was statistically at par values with G_7 (Green Romaine) (0.488) and G_1 (Red Butter Head) (0.390). Moisture % varied in different genotypes. It was significantly higher in G_2 (Green Ice-berg) (97.64%) being at par with G_4 (Dublin) (96.69%) and G_5 (Garishma) (96.68%). Starch percentage (19.35%) and reducing sugar (2.043%) were highest in G_5 (Garishma). Whereas genotype G_3 (Revolution) resulted in lowest values of starch (3.54%) and reducing sugars (1.183%). Non reducing sugars were maximum in G_1 (3.403%). These were minimum in G_3 (Revolution) (0.673%). Total sugar percentage exhibited significant variation. Its maximum values were found in G_1 (Red Butter Head) (5.090%). It was lowest in G_3 (Revolution) (1.183%). Sodium was maximum in G_6 (Bergamo) (34.42 mg/100g). Its minimum value was found in G_2 (Green Ice-berg) (31.50 mg/100g). Similar studies were also undertaken by Dolma and Gupta (2011) and Gupta *et al*. (2009).

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