Identification of valuable traits for lettuce (Lactuca Sactiva L.) breeding using analysis methods

Ravza Mavlyanova[1*], *Alisher* Shokirov[1], *Mirzaosimjon* Mirzasoliyev[1], *Jakhongir* Mengniyozov[1], *Hanifa* Hamdamova[2], and *Luiza* Khaknazarova[3]

[1]Research Institute of Vegetable, Melon crops and Potato, Tashkent, Uzbekistan
[2]Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
[3]Jizzakh State Pedagogical University, Jizzakh, Uzbekistan

Abstract. The article presents the results of studying 110 variety samples of 5 varieties (var. sativa, var. angustan, var. longifolia, var. crispa, var. capitata) of lettuce (Lactuca sativa L.). When grown in hot conditions of the Central zone of Uzbekistan, the duration of the growing season from mass shoots to economic suitability for leaf lettuce (early ripening) is 37-45 days, late ripening - 48-55 days, and headed lettuce - 54-67 days. Depending on the variety of lettuce, the yield is up to 4.0 kg / m2. Significant variability in yield and plant weight of lettuce during spring sowing was established, depending on climatic conditions, origin and varietal characteristics. Potential opportunities for improving the indicators of economically valuable traits of lettuce variety samples using probabilistic and statistical methods of analysis are discussed. The average values and limits of yield and plant weight characteristic of varietal diversity within the species when growing lettuce in open ground have been determined. Based on the methods of variation statistics, the selection criteria for the source material have been developed, taking into account a differentiated approach to lettuce diversity.

1 Introduction

Among vegetable crops, lettuce (Lactuca sativa L.) deservedly receives attention. It is the main source of vitamins and biologically active substances, many of which are absent in other products.

According to the Department of Statistics of the Republic of Uzbekistan, in 2022, the sown area under green vegetable crops amounted to more than 70 thousand hectares, and the gross production amounted to more than 1 million tons, of which lettuce accounted for 8%.

Lettuce has 12 stages of organogenesis. The duration of the organogenesis stages depends on many factors, among which many researchers highlight the biological characteristics of the variety and its growing conditions [1;45]. According to Wagenvoort (1981), lettuce seeds require 600 to 2000 degrees for germination.

* Corresponding author: shoxsita123@gmail.com

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

In lettuce, the formation of leaves depends on the variety and growing conditions. The assimilation surface area of the leaves varies among different types of head lettuce, with the highest value being 860 for some varieties, the average being 1014, and for late-ripening varieties this figure is different - 1170 [2;78].

Early-ripening varieties of head lettuce are classified as long-day plants. Late-ripening varieties have a neutral reaction to day length. They are capable of forming dense heads of cabbage in spring and summer. With short days, early-ripening varieties of lettuce accelerate growth and development. Reducing the day to 9-10 hours promotes leaf growth, increases the size of the head, and delays seed formation [3;490].

Many researchers note the importance of isolating the source material for breeding lettuce for early maturity.

In leafy varieties of lettuce, the leaves are located on a short stem. In head varieties, the leaves are wrapped in heads of varying size, shape, and density. During the process of head formation, the inner leaves gradually close with the outer ones. You can observe the diversity in the shape, size, color, texture and consistency of the leaves depending on the variety.

The stem formation phase is important for characterizing the economic value of varieties. Evaluation by the transition to stem formation makes it possible to select the most productive of them with long-lasting commercial qualities. Studies have shown that temperature and air humidity do not affect the rate of stem formation in plants; the determining factor is the duration of daylight. Lack of moisture accelerates stem formation, especially at high temperatures, and negative temperatures also accelerate this process.

Lettuce flowers are very small, usually grouped into inflorescences of 12-16 pieces. Japanese scientists have found that temperatures above 20 ° C contribute to faster formation of flower buds and elongation of the peduncle. The processes occurring in lettuce plants during generative development accelerate with increasing air temperature. Even early varieties did not flower at lower accumulated temperatures, remaining at the stage of inflorescence formation. Lettuce flowering depends on the photoperiod [4;90]. Lettuce is predominantly a facultative self-pollinator, although in southern regions some varieties demonstrate cross-pollination rates of 3-19%. (M.M. Girenko et al., 1988). In Holland, Italy, France, England, Germany, the USA, Canada and other countries where lettuce occupies a larger area, diverse studies are being conducted aimed at creating the most productive and disease-resistant varieties [5;321].

There is extensive information in the literature on the racial composition of disease populations and the genetic basis for the resistance of lettuce varieties and cultivars. Many researchers have published the results of assessing lettuce for resistance to the most harmful diseases: powdery mildew and downy mildew, septoria, white and gray rot, bacteriosis, mosaic, leaf edge burn, and have isolated the source material for selection [6;391].

Lettuce resistance to viruses has been revealed depending on the content of chemicals (Chadwick et al, 2013). Chemical mutagenesis [7;21], intervarietal and interspecific hybridization [8;65] are used in selection for resistance to diseases.

There is a lot of information on successful cultivation of lettuce in open and protected ground. Many researchers have noted the variability of the yield of zoned varieties depending on the cultivation zone Wiebe HJ & Krug H. (1985). According to these authors, the yield of leaf lettuce in open ground is 8-15 t/ha, with winter cultivation 12-15 thousand heads (almost two times lower than with spring due to freezing), in protected ground 2-3 kg/m2, and for varieties of Dutch selection - 2.9-6.6 kg/m2.

In Uzbekistan, lettuce is grown in open ground, where the yield of leaf lettuce is 5-8 to 10 t/ha, and of head lettuce 8-12 and up to 15 t/ha [8;432].

Leaf lettuce, when sown in autumn under film, yields 14 t/ha, in open ground 10.0 t/ha, when sown in winter under film 10.3 t/ha, and in open ground - 9.0 t/ha, and when sown in spring - 8.6 t/ha. The yield of lettuce in greenhouses is 2.3 - 3.3 kg/m2, [9;12].

The trait most susceptible to phenotypic variability in F1 lettuce varieties and hybrids is the weight of the head. Such features as the number of leaves in a head, length, width, leaf area have an average variability.

Research conducted by scientists abroad indicate great potential for using this valuable crop, as well as for isolating valuable source material for selection from varietal diversity [10;23]. [11;45].

Most experts highlight lettuce varieties such as Krupnokochanny, Khrustalny, Kuk-shokh, as well as Dutch varieties Noran, Ostinata, Amplus, Rapide, Deci-Minor, as high-yielding, resistant to premature stemming and diseases. To increase vegetable production, it is necessary to create and introduce into production high-quality varieties and hybrids that can increase the yield and quality of products by 20% due to the varietal properties of plants.

In Uzbekistan, mainly foreign varieties and hybrids of lettuce are used, while only one domestic variety, Kuk-shoh, was zoned in 2002. Existing varieties and hybrids do not fully meet the requirements of modern production. The world diversity of lettuce includes many varieties with valuable properties, the study of which and the development of seed production methods have prospects. The introduction of new varieties and hybrids in Uzbekistan will help to increase the yield and quality of products, as well as expand the range.

For the effective selection of source material, it is necessary to create collections by key features and form a gene pool database. This will allow breeders to rationally use the source material and contribute to the creation of new high-quality varieties and hybrids.

Research on lettuce culture in the republic is insufficient and is limited mainly to the technologies for cultivating a zoned variety. In connection with the tasks set before breeders, an in-depth study of the gene pool and the allocation of source material for selection are relevant areas. The aim of the present research was to comprehensively assess the diversity of lettuce crops using probabilistic and statistical methods of analysis, to identify source material for selection and to develop recommendations for the rational use of sources of economically valuable traits in practical selection work.

2 Methods

Characteristics of the studied varietal material. The study included 110 lettuce (Lactuca sativa L.) varieties belonging to 5 species (var. sativa-sown, var. angustan-narrow-leaved, var. longifolia-long-leaved, var. crispa-curly, var. capitata-headed) originating from 12 countries.

Climate conditions: The climate is characterized by significant daily and annual temperature fluctuations, seasonal changes in precipitation, concentrated in winter and spring, as well as an abundance of light and heat (Babushkin, 1972). The annual duration of sunshine ranges from 2692 to 2889 hours. There are more than 240 sunny days per year, of which 23-25 days in summer and 4-5 days in winter.

Soil conditions: The main chemical characteristics of Central Asian soils include low humus content, high carbonate content, low cation exchange capacity, high base saturation, relatively uniform chemical composition throughout the soil profile, and frequent salinization with soluble salts. The soils used for field experiments are typical of old-irrigated chernozems. Groundwater occurs at a depth of 330-400 meters below the soil surface, and canals are the source of irrigation water.

3 Research methodology

The study of lettuce varieties was carried out in compliance with the guidelines for the study of cabbage and leafy green crops (lettuce, spinach, dill) collections. VIR, 1969.

The collection varieties were studied during three-year field experiments. The study of collection variety samples was carried out in a single replication on plots of 4.5 m x 0.7 m. The standard was sown every 10 plots. Zoned varieties of lettuce were used as standards - Kuk-shokh and Krupnokochanny.

In the spring period, lettuce was sown in the field in March. Lettuce seeds were sown in one row, the distance between lettuce plants was 30 cm.

Phenological observations. Phenological observations were carried out on collection crops: single and mass shoots, the date of onset of economic suitability for 50, 75 and 100% of plants in the plot. Interphase periods were determined in days.

Harvesting of leafy varieties of lettuce was carried out in the II-III decades of May at the onset of 100% economic readiness, and head varieties of lettuce - as commercially suitable heads formed.

During harvesting, a visual assessment of the uniformity of the samples was carried out, taking into account the number of marketable, underdeveloped, deformed, diseased plants and flowering specimens. The total and marketable yield, the number of defects, as well as the average weight of one plant were determined. Taste qualities were assessed by tasting.

Morphological features: To determine varieties and study the variability of morphological features of varieties, samples were described in the leaf rosette phase, 10 plants of each variety were described.

Disease resistance: The degree of disease damage was recorded three times during the growing season at 10-day intervals. The resistance of varieties to diseases during natural infection was assessed using a six-point scale:

- 0: no signs of disease;
- 0.1: very slight damage to lower leaves;
- 1: up to 10% of the surface is affected, mild symptoms and sporulation;
- 2: up to 25% of the leaf surface is affected, typical symptoms, moderate sporulation;
- 3: up to 50% of the surface is affected, pronounced symptoms, typical sporulation;
- 4: more than 50% of the surface is affected, typical symptoms are strongly expressed, partial necrosis, abundant sporulation.

Based on the accounting data, expressed in points, the disease development index was calculated for each sample using the formula, where R is the disease development index in percent; Σ (r b) is the sum of the products of the number of affected plants (r) by the corresponding damage score (b); n is the number of plants counted; 4 is the highest damage score on the scale.

For a full immunological assessment of the studied variety, the type of resistance was determined based on multiple assessments, expressed in points:- type 0 - resistant varieties (score 0);

- Type I - practically stable (score 0.1-1);
- Type II - weakly susceptible (score 2);
- Type III - moderately susceptible (score 3);
- Type IV - highly susceptible varieties (score 4). Statistical analysis of all experimental data was carried out according to B.A. Dospekhov (1985). Variation series constructed on the basis of the obtained experimental data on the yield and chemical composition of the studied lettuce variety were analyzed. The average long-term ( ), minimum and maximum values and took into account the standard deviation of the values of the varietal trait from the average (S), which is the main indicator of the magnitude of the environmental variability of the varietal trait, and also used the variation coefficient (Vg,%), which characterizes the degree of variability of the trait depending on changing climatic conditions. The coefficient of agronomic stability of the manifestation of a varietal trait (As, %) and potential values of the trait under optimal environmental conditions (xp) were calculated. The variation of attribute (qualitative) traits of varieties and populations was analyzed: marketability of the

yield, flowering of plants using the variability index (S). Based on statistical data processing, polygons and histograms of frequency distribution for lettuce crops were constructed.

4 Results and discussion

Biological features. Seed germination and emergence of seedlings. In our studies, no difference in the timing of emergence of seedlings in lettuce varieties depending on their geographical origin was observed. The emergence of seedlings depended on the temperature and soil moisture. With early spring sowing, when the soil temperature was +10 ... + 12 ° C and there was sufficient precipitation, lettuce seeds germinated on the 13-15th day. At a lower temperature of +2 ... + 5 ° C and insufficient precipitation, the emergence of seedlings was delayed up to 22 days.

Leaf formation. Early-ripening lettuce varieties began to form a head after the formation of 5-7 leaves, the diameter of the leaf rosette was on average 15 sm, the diameter of the head was 5 - 6 sm. For mid-ripening lettuce varieties, these indicators were, respectively: 7 - 9 leaves, 20 sm and 6 ... 9 sm; in late-ripening varieties - 8-9 leaves, 26 sm and 8 ... 12 sm.

The duration of the period from mass germination to economic suitability of the studied varieties varied depending on climatic conditions. Under favorable conditions, the earliest ripening leafy varieties of lettuce reached full economic suitability on the 37th - 45th day, and in late-ripening varieties on the 48th - 55th day after mass germination. With an increase in air temperature in May to +20 ... +230C and a decrease in air humidity to 43-47%, the growth rate of plants slowed down. Intraspecific variability in the duration of the growing season of lettuce was significant. Differences in ripening times were observed in leafy and head varieties. The difference was 6 - 12 days. Early-ripening varieties of leaf lettuce were identified (Table 1), in which 50% of the economic suitability of the leaves occurred on the 32nd - 35th day, and full economic suitability on the 37th - 45th day after germination. These are varieties of sowing (var. Sativa) and curly (var. crispa) lettuce originating from Germany, the Netherlands, Spain, Russia, Iran, Turkey, Korea, Laos, Japan, and the USA. Among them, the earliest (on the 37th day) ripening local varieties from Azerbaijan (K - 1486), Iran (K - 1280) and Laos (K vr. 1444).

Most of the identified varieties of leaf lettuce are distinguished by a yield higher than the average due to the dense standing of plants weighing from 37 to 100 g.

Basically, the head varieties were late-ripening in comparison with the leaf varieties. There are a number of early maturing varieties of head lettuce originating from the Netherlands, the Czech Republic, Cuba, the USA, Australia and Japan, which form a small loose head 41-45 days after germination. In terms of overall yield, they are close to some high-yielding leafy varieties and have a larger plant weight (100-180 g) compared to them with sparse plant growth. An important property of lettuce plants is the duration of their economic shelf life, when the plants do not immediately form a stem, thereby extending their consumption period. We divided the variety of varieties by the duration of their economic shelf life into three groups: 1) up to 10 days; 2) 10-20 days; 3) more than 20 days. The studied lettuce varieties do not show any pattern in the duration of their economic shelf life depending on their belonging to a certain variety. Varieties of leaf lettuce selected for early maturity originating from the USA, Iran, Turkey, Korea and Laos have a short period of commercial shelf life (up to 10 days) and then begin to form stems.

Table 1. Sources for selection of lettuce for early maturity

Variety, origin	Vegetation period (days) from germination to:					Productivity, kg/m2	Average plant weight, g
	commercial suitability		beginning of stem formation	mass blooming	ripening of seeds		
	50 %	100 %					
Leaf salad							
Kuk-shoh, Uzbekistan - standard	35	44	57	87	109	2,1	100
Kraser gelber, Germany	32	43	56	93	108	1,9	37
Bush, Germany	32	43	56	89	106	2,6	47
Local, Azerbaijan	32	37	62	89	104	1,0	46
Black seeded simpson, Netherlands	32	43	63	96	109	1,1	51
Local, Iran	32	37	43	82	101	1,9	60
Untitled, Turkey	35	40	49	76	87	1,1	66
Gusen Buru, Korea	35	44	52	96	111	2,1	54
Gusen Buru, Korea	32	40	49	81	95	2,7	40
Inburu, Korea	35	44	54	87	108	1,9	53
Zazu Buru, Korea	35	44	49	74	94	1,5	55
Local, Laos	35	40	49	76	87	1,1	57
Local, Laos	32	37	47	72	84	1,0	33
Prize mead, USA	35	44	59	92	104	1,8	58
Early leafy, USA	32	44	49	93	106	1,3	59
Waldwans green, USA	32	43	56	96	106	1,9	40
Green wave, Japon	32	43	63	108	121	2,1	100
Untitled, Japan	32	43	54	95	108	2,1	90
Vanmax, USA	35	43	61	89	104	2,2	64
All the ycarrand, Spain	35	45	57	91	100	1,1	55
Head lettuce							
Formidano, Netherlands	32	43	63	91	110	1,9	105
Lustrona, Netherlands	32	43	63	89	106	1,6	100
Glacial, Netherlands	32	43	65	90	110	1,8	130
L 8785, Netherlands	35	45	70	94	115	1,7	153
Eissalat, Netherlands	35	43	63	95	108	1,8	150
Ledowy, Czechoslovakia	32	43	65	108	121	2,4	180
Great lakes, Sweden	35	45	71	103	113	1?8	160
LD-11, Cuba	32	43	75	104	118	2,1	150
Sunbright, USA	32	45	69	103	115	2,0	141
New York	32	43	68	104	116	2?7	140

New York 12, Canada	35	45	69	99	115	1,9	102
Great lakes, Australia	32	45	68	102	115	1,9	107
Mikado lakes, Japon	35	45	68	98	111	2,3	186
On average for 110 varieties:							
				$\bar{x} \pm \int \bar{x}$		1,6 ± 0,05	
				LSD_{01}		0,9	

The varieties originating from Germany, the USA, Japan, Russia and Spain had a shelf life of 10-20 days. Some varieties originating from the Netherlands, Azerbaijan and Japan had a shelf life of more than 20 days.

Research has shown that to form an early commercial harvest, lettuce plants require a sum of effective temperatures above 10°C of at least 290°.

Stem formation: After reaching full economic maturity, lettuce plants did not remain in this phase for long and then began to form flower stalks. The process of stem formation depended on the biological characteristics of the variety and weather conditions. In most varieties of leaf lettuce, at elevated temperatures in the first ten days of June (+22 ... +25°C), stem formation began on the 60-65th day after emergence. The earliest stem formation (on the 43-49th day after emergence) was observed in early-ripening local leaf varieties from Iran, Turkey, Korea and Laos. In most head varieties, stem formation began on the 70-75th day after germination. In our conditions, the head varieties Webby Wonderful from Great Britain, Airelle from France, Krupnokochanny from Russia, Lechuga grandes from Spain, GL - II from Cuba did not form arrows for another 32-36 days after the onset of mass economic suitability. Later, on the 85-90th day after germination, after stem formation, they moved on to other phases of development, as a result of which they were distinguished by late-ripening seeds. It should be noted that many head varieties did not form a stem due to the impossibility of its germination through a dense head. We used the method of early release of the stem from the head by cutting it. After this technique, the stem of most varieties was released and began to grow.

Formation of inflorescences and flowering. In the early-ripening varieties of leaf lettuce that we studied, flowering began on the 61st - 66th day, in the mid-season varieties - on the 74th - 79th day, in the head varieties - on the 87th - 89th day after germination and lasted 15 - 20 days. Lettuce flowering took place in the first ten-day period of July, when the air temperature was +26 ... +28 °C, air humidity 39 - 48%, due to which the flowering rate was accelerated.

We have found that for the transition to flowering, early-ripening varieties of lettuce require a sum of effective temperatures of at least 580 °, mid-season varieties - 730 °, and late varieties - 1000 °.

Fruit formation and seed maturation: Among lettuce varieties, the shortest period from germination to seed maturation (84-90 days) was observed in varieties originating from Turkey, Laos and the USA. Most leaf and head varieties of lettuce ripened 95-110 days after germination. Late seed ripening (113-118 days) was typical of some leaf varieties from Zambia and Japan, as well as head varieties from Canada, the USA, Spain, the Netherlands, Greece, Germany, Argentina and Cuba. The latest seed ripening (120-135 days) was observed in some leaf varieties from Germany and Japan, as well as head varieties from France, the Czech Republic, England, the Netherlands and the USA. In leaf varieties with early onset of economic suitability, the seeds ripened in the early and middle terms, and in the head varieties - in the middle and late terms. Apparently, this is due to the rates of stem formation, flowering and seed ripening of different varieties.

A summary of the obtained data on the biological characteristics of lettuce shows that there are differences in the maturity groups. (Table 2). Research has shown that early-ripening lettuce varieties require a sum of active temperatures of at least 950° from germination to seed ripening, mid-season varieties require 1200°, mid-late varieties require 1400°, and late varieties require 1550°.

Table 2. Phases of lettuce development in the Central zone of Uzbekistan

Variety	Vegetation period from germination to:				Sum of active temperatures, deg.
	stem formation	flowering		seed maturation	
		start	mass		
leafy (early ripening)	43-49	61-66	68-74	84-50	950
leafy (late ripening)	60-65	74-79	78-85	95-100	1200
headed	70-75	87-89	95-105	113-135	1550

5 Disease resistance

In our studies, the diseases that have a high annual severity combined with widespread occurrence were leaf edge burn, mosaic and downy mildew.

Leaf edge burn (Bacterium marginale Brown.) is the most common non-parasitic disease. At the onset of the disease, individual brown spots form on the leaf edge, then they dry out, and the spots grow and can affect the entire leaf. The primary cause of leaf edge burn (Vlasova et al., 1974) is considered to be physiological disorders. The disease manifests itself with heavy precipitation and high air temperature.

Of the lettuce varieties we studied from 14 countries, no resistant to edge burn were found in the rosette phase. The development of the disease ranged from 0 to 32%, the spread from 0 to 100%. The lettuce varieties presented in Table stably retained practical resistance to edge burn. 3.

Table 3. Lettuce varieties distinguished by practical resistance to marginal leaf burn

Variety	Origin	Average defeat score		
		1	2	3
Imperial triuph	Australia	0,20	0,19	0,11
Phoemux great L	USA	1,4	0,2	0,02
New York	USA	0,09	0,14	0,05
Pennlake	Canada	0,67	0,10	0,23
Nabiccoh 8	Netherlands	1,2	0,9	0,5
J - 32	Netherlands	1,04	0,6	0,23
Jisbergsta	Netherlands	1,3	1,1	1,3
Bervenda	Netherlands	0,8	0,07	0,6
Juma	Netherlands	1,5	1,03	0,11
Fortininer	Finland	1,5	0,24	0,1
L - 1656	Finland	1,4	0,4	0,71
Great lakes 118	Denmark	0,92	0,83	0,13
	$\overline{x} \pm S\overline{x}$	1,9±0,09	0,6±0,07	0,31±0,03
	LSD_{01}	0,3	0,2	0,07
	Vg,%	36,8	81,3	64,5

Varieties from the Netherlands, where intensive work is being done to create disease-resistant varieties, turned out to be practically resistant to edge burn.

Mosaic virus is a viral disease. Leaves affected by the disease have jagged edges, are covered with wide light green or yellow stripes, or elongated specks, and the veins become lighter. At first, the leaves become wrinkled, then curl up and die.

In our studies, the spread of mosaic among varieties was insignificant during the years of study and amounted to 11.5% of the number studied. The development of the disease was the strongest (100%) out of three years only in one year. The varieties Imperial triuph from Australia, Diamant from Great Britain and Great lakes from the USA turned out to be highly susceptible. Other varieties were not affected.

Downy mildew (Bremia lactucae Regel.j.Sonchi (Schw.) Dehunuz) first affects the upper, then the lower part of the leaf. A white or grey-violet powdery coating appears on the leaves. In our studies, resistance to powdery mildew was noted in 24 varieties, which accounted for 50% of those studied. For other varieties, the development of the disease fluctuated between 2.2 and 100%. Severe damage was observed in the American varieties Cornell 456 and Great Lakes. Varieties with complex resistance to edge burn, mosaic and powdery mildew were identified. These are mainly American varieties New York special, New lakeland, Cornell 456, Vanmax, Sunbright, Colrey Great lakes (K - 1563), as well as Winter lake from Australia and Batavia de Piero from Belgium.

6 Morphological features

In salad, when selecting sources of economically valuable features, it is necessary to take into account the morphological features that determine the commercial appearance of the plant.

The studied varieties of salad revealed average variability in the length (Vg = 15.7%) and width (Vg = 12.8%) of the leaf, the number of leaves (Vg = 17.7%) and the diameter of the rosette (Vg = 19.3%).

Depending on the variety, the length of the leaf was 10-24 cm, the width 4-8 cm, the diameter of the rosette 15-30 cm, the number of leaves 12-30 pcs. Such varietal features as color, shape, nature of the leaf surface did not change. Due to the great diversity in morphological features, when choosing varieties, it is necessary to take into account the economic features, but the commercial appearance of the plant is decisive. They have economically valuable characteristics, but the varieties of narrow-leaved and long-leaved varieties, as well as some varieties of sowing (var. sativa) and curly (var. crispa) varieties with strongly pigmented leaves will not be able to find application as they do not meet consumer requirements. The lettuce varieties we have identified, related to sowing (var. sativa) and curly (var. crispa), headed (var. capitata) varieties, have a good marketable appearance and differ in shape. Rosettes have leaves that can be whole or cut, rounded, broadly obovate, kidney-shaped or fan-shaped. The color of the foliage varies from dark green and green to green with pigment and dark cherry. The edge of the leaf can be whole or finely serrated, weakly or moderately scalloped, and also with varying degrees of ruffles along the main nerve. The surface of the leaf can be cellular-swollen to varying degrees. Heads of cabbage varieties can be round, oval, round-flat, of different sizes and densities.

The consistency of the leaf is juicy, crispy or tender, oily. Various combinations of the noted features in varieties provide a great variety, allowing to expand the range of salad in Uzbekistan.

Productivity.

In the early spring period, preference is given to early ripening leafy varieties with delicate attractive leaves. The gene pool of lettuce is very diverse and, in this regard, the selection of initial material for breeding is promising here.

In our studies, lettuce varieties showed significant variability in yield (Vg = 54.3%) and plant weight of leafy (Vg = 53.3%) and head varieties (Vg = 55.1%).

The yield of leafy and head varieties did not differ sharply, since some head varieties did not form heads in hot conditions. and some leafy varieties formed a large rosette of leaves or their yield increased due to a large number of plants per unit area due to a compact rosette of leaves.

By yield, the varieties were distributed into nine classes with an interval of 0.4 kg / m2. About 60% of the studied varieties had a yield below the average (1.6 0.05). From 1.7 to 2.0 kg / m2 was the yield of 15% of varieties, from 2.1 to 2.8 kg / m2 - of 13.7% of varieties, from 2.9 to 4.0 kg / m2 - of 11.6 studied varieties. The obtained data indicate a high yield of many varieties of leaf and head lettuce in the conditions of Uzbekistan. Although the yield of lettuce was affected by temperature and air humidity, many varieties distinguished by high yield under favorable conditions also formed a higher yield in unfavorable conditions in comparison with other varieties. The yield variation curve shows the possibilities of selecting the source material. The limits are from 0.2 to 4.0 kg / m2. In the trait collection for selection, we consider it necessary to use leaf lettuce varieties with a yield higher than the Kuk-shokh standard, as well as head lettuce varieties with a yield higher than the Krupnokochanny standard. With distinctive positive traits (marketable appearance of plants) in some of the studied varieties, it is also permissible to use varieties with a yield exceeding the average statistical indicator. Within the lettuce species (Lactuca sativa L.), the varieties differed significantly in plant weight. In leaf varieties, the plant weight was from 25 to 150 g, in head varieties from 100 to 400 g. In terms of plant weight, leaf varieties were distributed in three classes with an interval of 50 g. Up to 100 g was the plant weight of 93% of varieties. Headed varieties were distributed in six classes and more than half of the varieties had a weight of 100 to 200 g. From 11.3 to 15.7% of the varieties were distributed in three classes from 200 to 230 g. Only 4.4% of the studied varieties had the largest plants.

Leafy varieties can form a rosette with an optimal and dense plant stand, and head varieties form commercial plants only with a sparse stand.

The variation curve of plant weight for leafy varieties has two peaks with a high frequency (43 and 50%), and for head varieties the distribution has lower frequencies.

In the trait collection of leaf lettuce, during selection, it is more advisable to use varieties with a plant weight higher than the average and standard, since in many leafy varieties the yield increases due to the dense plant stand. In head varieties, the average and standard plant weights are close in indicators and these indicators should be taken into account during selection. A number of varieties of leaf and head lettuce with high stability of characteristics were selected as sources for selection for yield. The varieties of leaf lettuce of the varieties sativa (var. sativa) and curly (var. crispa) stand out with a yield of 1.7 - 2.8 kg/m2. The most productive (2.1 - 2.8 kg/m2) were the varieties New York, Vanmax, Waldwans green from the USA, White Boston from Canada, Black seeded simpson from the Netherlands, Local from Iran, Gond buru from Korea and Green wave from Japan. They were distinguished by high stability of yield (49 - 92%) and plant weight (69 - 92%). The potential yield of the best varieties reached 5.5 kg/m2. The varieties of head lettuce that stand out for their productivity come mainly from the Netherlands, Finland, Sweden, Belgium, France, the Czech Republic, Canada, Cuba and Japan, where much attention is paid to the selection of varieties and high-quality varieties have been created that have spread to other countries. The most productive (2.6 - 3.4 kg / m2) with high stability (48 - 87%) varieties of head lettuce Astral and R - 100 from the Netherlands, Great lakes from Canada have been identified. Their potential productivity reaches 6.1 kg / m2 (Table 4).

Table 4. Sources for selection of lettuce for productivity.

Variety, origin	Productivity, kg/m2					Plant weight, g			
	$\bar{x}$	x_{min}	x_{max}	A_S, %	x_p	$\bar{x}$	x_{min}	x_{max}	A_S, %
Leaf lettuce. var. saliva - variety sowing									
Kuk-shoh, Uzbekistan - standard	2,1	1,3	2,4	61	4,8	100	87	115	79
New York, USA	2,7	2,5	2,8	92	5,4	60	52	69	69
Vanmax, USA	2,2	1,4	3,9	49	4,9	74	56	93	81
Early leafy, USA	1,8	1,3	2,3	59	4,5	53	50	65	86
Bonival gelber, Germany	1,7	1,6	1,8	91	4,4	51	45	55	95
Kraser gelber, Germany	1,9	1,2	2,6	45	4,6	47	45	50	86
Gellow Curled, Hungary	1,8	1,2	2,8	59	4,5	47	43	57	65
Local, Iran	1,9	1,2	2,4	53	4,6	78	60	98	51
Local, Iran	2,3	1,6	3,1	51	5,0	48	43	54	71
Gusen Buru, Korea	2,1	1,2	3,1	33	4,8	74	58	91	54
Gond Buru, Korea	2,7	2,2	2,9	81	5,4	60	42	78	33
var. erispa –curly variety									
Green wave, Japon	2,1	2,0	2,2	93	4,8	100	94	105	92
Waldwans green, USA	2,1	2,0	2,2	93	4,8	60	55	64	83
Black seeded simpson, Canada	1,9	1,1	2,6	41	4,6	52	48	64	91
Grand Rapids, Canada	1,6	1,4	1,8	82	4,3	65	59	82	45
Bronze beanty, Kanada	1,7	1,2	2,5	69	4,4	46	40	56	43
White Boston, Canada	2,3	1,1	2,9	41	5,0	58	51	62	79
Yellow Curly, Germany	2,0	1,2	2,4	55	4,7	46	41	50	75
Black seeded simpson, Netherlands	2,8	2,5	3,2	81	55	52	48	56	81
On average for 78 leaf varieties:									
$\bar{x} \pm S\bar{x}$					56,8 ± 1,8				
LSD_{01}					63				
V_g, %					53,3				
Head lettuce. var. capitata - head variety									
Large-headed,Russia-standard	2,5	2,0	3,5	55	5,2	152	109	267	68
Great Lakes, Canada	3,4	2,2	3,7	67	6,1	195	140	262	73
GL-11, Cuba	2,1	1,7	2,9	58	4,8	150	127	205	61
Eissalat, Netherlands	1,8	1,6	2,2	67	4,5	156	137	227	55
Astral, Netherlands	3,4	3,1	3,7	87	6,1	206	154	250	63
Starlina, Netherlands	2,0	1,2	3,3	32	4,7	159	115	227	54
R-100, Netherlands	2,6	1,8	3,6	48	5,3	180	113	360	22

L-8785, Netherlands	1,7	1,4	2,7	43	4,4	224	124	307	40
Fortininer, Finland	2,2	1,9	3,5	46	4,9	220	165	400	24
L 1656 Sb, Finland	2,2	1,8	3,5	43	4,9	255	180	337	67
Great lakes? Idtwbz	1?8	1?3	2?4	54	4?5	260	162	380	36
Batavia de Pierre, Belgium	1,6	1,3	1,9	72	4,3	203	157	257	63
Tehue de nimes, France	2,5	1,9	2,8	70	5,2	150	130	195	68
Covallon, France	2,4	2,1	2,8	78	5,1	150	126	208	64
Ledovy, Czechoslovakia	2,4	2,0	2,6	81	5,1	180	154	200	81
Mikado Lakes, Japon	2,3	1,6	3,0	54	5,0	186	127	281	38
On average for 110 varieties:									
$\bar{x} \pm S\bar{x}$	1,6 ± 0,05								
LSD_{01}	0,87								
$S\bar{x}$, %	3,1								
V_g, %	54,3								
On average for 32 cabbage varieties:									
$\bar{x} \pm S\bar{x}$						149 ± 12,5			
LSD_{01}						22,2			
V_g, %						55,1			

Although the varieties of head lettuce belong to the same variety, they differ in plant type, which provides a wide choice of source material for targeted selection. Leaf varieties also show a wide variety in shape, color and habit of plants. Yield variability depended on sowing time. When lettuce was sown in open ground in September, the plants formed a rosette of leaves, which began to grow back after overwintering and the yield of products was formed in early spring. Significant yield variability was observed (Vg = 27.9%). In leaf varieties, the yield varied from 1.7 to 2.1 kg / m2, in head varieties from 1.9 to 3.5 kg / m2. The average yield was 2.4 0.1 kg / m2, since there were more head varieties in the studies. The yield variation curve revealed the presence of source material with indicators above the standard, which should be taken into account during selection. In terms of plant weight, most of the head varieties exceeded the standard, which makes it possible to select varieties with large plants.

In terms of yield (2.0 - 2.1 kg/m2) and plant weight of 100 - 120 g, the following leaf varieties stood out: Waldwans green from the USA, All the ycarrand from Spain, Green wave and K - 1790 from Japan, as well as the head varieties Khrustalny from Russia and Kovallon from France with a yield of 3.0 - 3.5 kg/m2 and plant weight of 154 - 308 g.

A summary of long-term data allowed us to establish species variability in yield and plant weight of different lettuce varieties when grown in the hot climate of Central Asia (Table 5).

Table 5. Species variability in yield and plant weight of lettuce when grown in the Central zone of Uzbekistan

Cultural	Standard indicators, kg/m2	Indicators of the studied varieties			% varieties that exceeded	
		$\bar{x} \pm S\bar{x}$	Limit	Vg,%	$\bar{x}$	standard
Lettuce (spring sowing) [1]	2,5	1,6±0,05	0,2-4,0	54,3	41	17
Leaf lettuce	100	57±1,8	5-150	63,3	50	-

Head lettuce	152	149±12,5	100-400	55,1	39	79

Note: 1 - yield, kg/m2; 2 - plant weight of leafy varieties, g; 3 - plant weight of head varieties, g.

7 Conclusions

When grown in hot conditions of the Central zone of Uzbekistan, the duration of the vegetation period for leaf lettuce (early ripening) is 37-45 days, late ripening - 48-55 days, headed lettuce - 54-67 days from the moment of mass shoots until reaching economic maturity. The yield, depending on the variety of lettuce, can reach 4.0 kg / m². Significant variability in the yield and weight of the lettuce plant during spring sowing was revealed, which depends on climatic conditions, origin and varietal characteristics. Average values and limits of yield and plant weight, characteristic of varietal diversity when growing lettuce in open ground, were established. Trait collections should cover the entire spectrum of intraspecific diversity in breeding-valuable traits. The criteria for selecting the source material that we developed, based on the methods of variation statistics, take into account a differentiated approach to the diversity of lettuce. Trait collections for lettuce culture have been formed, and the following grouping of varieties has been proposed: a) with a low trait value — below the statistical average; b) with an average trait value — corresponding to the statistical average taking into account the least significant difference (LSD01); c) with a high trait value — above the average level plus LSD01. For selection for yield, it is necessary to select the source material with trait stability of at least 60% and a yield higher than the standards for head lettuce. When selecting the source material for selection for yield, it is recommended to select varieties of leaf and head lettuce with a yield higher than the standard values. In the presence of other valuable traits, such as the marketable appearance of plants, it is possible to select varieties with a yield higher than the average. The selection of varieties by plant weight is carried out in a similar way. As a result of the research, variety samples with high stability of traits were selected for selection: 30 — by early maturity, 22 — by disease resistance, 32 — by yield. The source material for selection for yield from different countries has been determined. The varieties with a yield of 1.8-2.8 kg/m² from the Netherlands, Germany, Hungary, USA, Canada, Japan, Iran, Korea are promising for the selection of leaf lettuce, and the varieties with a yield of 1.6-3.4 kg/m² from the Netherlands, Finland, Sweden, Belgium, France, Czech Republic, Canada, Cuba and Japan are promising for the selection of head lettuce. The following lettuce varieties have been identified based on a set of economically valuable traits: Crauser gelber from Germany, Covallone from France, Eissalat and Astral from the Netherlands, Green wave from Japan. Our studies allow us to take a reasoned approach to the selection of source material and indicate the advisability of replenishing the collection with new foreign varieties. The study of the diversity of lettuce crops shows the potential of using the varieties we have selected for the selection of new high-yielding, high-quality varieties and the introduction of new varieties of lettuce in Uzbekistan for cultivation in open ground in the spring.

References

1. L.N. Babushkin, On agronomic zoning of the republics of Central Asia. Scientific tract SANIGMI, Samarkand, 400-419. 1972.
2. A. Bakiev, S. Makhkamov, Green and rare vegetable crops. Book, 61. 1987.
3. Balashev NN & Zeman GO . 1972. Vegetable production. Book, 424.
4. Brunner, H. 1982. Mutations kersuch bei salat. Pl. Breed., 52 (7), abst. 6072.

5. Candresse, Th., Le Gall, O. & Marianne, M. (2006). Virus susceptibility and resistance in lettuce. In book: Natural Resistance Mechanisms of Plants to Viruses, 383-397. DOI:10.1007/1-4020-3780-5_17.
6. https://www.researchgate.net/publication/227119127_Virus_Susceptibility_and_Resistance_in_Lettuce
7. Carlson, G. 1981. Ny isbergssalat for vaxthusoding. Viola Tradgardsvarlden, 51-52.
8. Chadwick, M., Trewin, H., Gawthrop, F. & Wagstaff, C. Sesquiterpenoids (2013). Lactones: benefits to plants and people. J. Mol. Sci., 14(6), 12780-12805. https://doi.org/10.3390/ijms140612780
9. Crute, R. & Johnson AG. 1979. The genetic relationship between races of Bremia lactucae and cultivars of Lactuca sativa. Ann. Appl. Biol., 83, 125-137. https://www.apsnet.org/publications/phytopathology/backissues/Documents/1982Articles/Phyto72n10_1363.PDF
10. Krause, W. 1983. Selecting varieties to play the market. Grower, 99 (21), 23-25.
11. Lizgunova, TV (1969). Guide for studying a collection of cabbage and leafy green crops (lettuce, spinach, dill). VIR, 44.
12. Maisonneure, B., Chureau, MC, Bellec, I., Chureau, I. 1995. Sexual and somatic hubridization in the genus Lactuca. Euphytica, 85 (1/3), 281-285.
13. Mayno, A. 1983. Liestunsprufung von Kopfsal. Gemuse, 19 (14), 44-47.
14. Netzer, D. 1971; Identification of races of downy mildew (Bremia lactucae Regel.) in Israel and breeding for resistance. J. Agric. Res., 21 (4), 143-144.
15. Norwood, JM, Johnson, AG., O'Brien, M. & Crute, JR. 1985. The inheritance of field resistance to lettuce downy mildew (Bremia lactucae) in the cross "Avonerisp"x"Iceberg". Z. Pflanzenzucht, 94 (3), 2559-2562.
16. Pantielev, YKh. 1991. Headed lettuce. Brochure, 95.
17. http://ay.by/lot/retro-sssr-pantielev-ya-h-kochannyj-salat-1991-5032413725.html
18. Parra, L., Maisonneuve, B., Lebeda, A., Schut, J., Christopoulou ,M., Jeuken, M., McHale, L., Truco, MJ., Crute, I. & Michelmore, R. (2016). Rationalization of genes for resistance to Bremia lactucae in lettuce. Euphytica, 210 (3), 16. DOI:10.1007/s10681-016-1687-1
19. https://www.researchgate.net/publication/301797715_Rationalization_of_genes_for_resistance_to_Bremia_lactucae_in_lettuce/link/5fbd46a4a6fdcc6cc6636605/download
20. Pink, DAC & Mc.Clement, SI (1995). Utilization of genetic resources in lettuce breeding in the United Kingdom. Zahradnictvi, 22 (4), 129-131.
21. Soleimani, P., Mosahebi Gh. & Mina KH (2011). Identification of some viruses causing mosaic on lettuce and characterization of Lettuce mosaic virus from Tehran Province in Iran. African Journal of Agricultural Research, 6 (13), 3029-3035. DOI: 10.5897/AJAR11.114/ https://academicjournals.org/journal/AJAR/article-full-text-pdf/E53C57B36172/
22. Van Treuren, R., van der Arend, AJM & Schut, J. 2011. Distribution of downy mildew (Bremia lactucae Regel) resistances in a genebank collection of lettuce and its wild relatives. Plant Genetic Resources 11 (1), 1-11. DOI:10.1017/S1479262111000761. https://www.researchgate.net/publication/231753973_Distribution_of_downy_mildew_Bremia_lactucae_Regel_resistances_in_a_genebank_collection_of_lettuce_and_its_wild_relatives
23. Vries, IM 1997. De origin and domestication of Lactuca sativa L. Genetik Resources and Crop Evolution, 44 (2), 167-174.

24. Vlasova, EA &Komarova, RA. (1974). Study of the main diseases of lettuce in protected ground of the Leningrad region. Applied Botany, Gen. and Sel., 53 (2.), 185-194.
25. Waycott, W. (1995). Photoperiodic response of genetically diverse lettuce accessions. J Am. Soc. Hortic, Sci,, 120, 460–467. https://doi.org/10.21273/JASHS.120.3.460
26. Wiebe, HJ & Krug, H. (1985). Einfluq der gageslange auf enturcklung und wachsh von kopfsalat (Lactuca sativa var capitata). Gartenbauwissenschaft, 50 (5), 202-206.
27. Wagenvoor, W. (1981). Optimum temperature range for germination of vegetable seeds. Gartenbau, 46 (3), 97-101. https://hilo.hawaii.edu/panr/writing.php?id=245
28. Wilhelm, E. & Metz, G. 1981. Kopfalasorten fur Spatherbs. Gartenbau, 35 (34), 1388-1389.
29. Wurr, DC & Fellows, JR. 1984.The growth of three crips lettuce varieties from different sowwing dates J. Agr. Sci., 102 (3), 733-745.
30. Zeman, GO & Trippel VV (1973). Peculiarities of vegetable crop cultivation in Tajikistan. Book, 48.