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RESEARCH COMMUNICATION

Growth and development of *Lycium barbarum* L. in the environment of Samarkand in Uzbekistan

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ABSTRACT
Shrub *Lycium barbarum* belongs of the family Solanaceae, is introduced and does not occur naturally in Uzbekistan. Despite its numerous medicinal characteristics, in Uzbekistan, its growth and development have not been studied. Therefore, our primary goal was to study the germination of seeds, stages of ontogenesis and some morphological signs of fruits. The highest seed germination rate of 74±0,12% as at the 20 ˚C. When studying ontogenesis, plant development was divided into ten stages and four periods. The pre-reproductive period lasted 1-2 years. The reproductive period was determined for 2-3 years from the beginning of the growing season. For several months, an analysis of the changes in the morphological characteristics of the fruits of *L. barbarum* was carried out and in May, relatively large ripened fruits were determined (length 2.18 ± 0.09, width 1.14 ± 0.11).

Introduction

Since the beginning of the 21st century, wolfberries (*Lycium barbarum*) a traditional food and medicine in East Asia, have become increasingly popular in Europe and North America. Numerous products are commercialised under the relatively new name Goji on the health food market (1).

Some functional foods with antioxidant and free radical scavenging activity, such as Goji berries, currently represent the focus of many scientific studies, which aim to evaluate their nutritional and health-promoting properties, when associated to a correct lifestyle and nutrition (2). Goji berries, the fruits derived from *L. barbarum*, is a local food in China and other Asian countries. China is the first world producer with 82000 hectares of acreage and 95000 tonnes of berries produced per year (3).

Modern medical research has found that the *L. barbarum* fruit contains several functional ingredients, polysaccharide (LBP), sugar, betaine, carotenoids, flavonoids and pharmacodynamic amino acids (L-aspartic acid (Asp.), glutamic acid (Glu.), glycine (Gly.), DL-methionine (Met.), Leucine (Leu.), tyrosine (Tyr.), lysine (Lys.), L-phenylalanine (Phe.), L-arginine (Arg) (4-9). The *L. barbarum* is considered to have immune-enhancing, anti-aging, cancer prevention and anti-oxidative properties. The wolfberry fruit is also rich in sugar and organic acids. Among these ingredients, LBP is considered as the most important bioactive with pharmacological effects followed by betaine and flavonoids (10).

In Uzbekistan the genus *Lycium* is represented by *L. ruthenicum* Murr., *L. dasystemum* Pojark., and *L. depressum* Stocks (11). *L. barbarum* is introduced and does not occur under natural conditions. It attains a height of 2–2.5 m with long branches. Leaves are green on the upper side whereas it is glaucescent on the lower portion, with side veins, tightly inverse lanceolate, elliptic lanceolate or narrow and elliptic, with the blunt, sharp or pointed top and tightly clinoid base. The sheet plate is 2–3 cm long and 2.5–8 mm wide. The scape is 3–5 times shorter than a plate. Flowers are pale violet, on the lengthiest up reinforced pedicels 5–15 mm long, on 1–4 in bosoms of leaves. Calyx 4–5 mm long and campanulate. The nimbus 11–15 mm long, funnel-shaped, with the tube considerably exceeding longwise bending in the bottom narrow cylindrical, then gradually funnel-shaped and expanded, outside of naked, is higher than

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attachment of stamens with a pilar and felt ring inside. Corolla is five partite, light, pink or it is violet - pink, with more dark veins and the bases of shares. Bending shares ovoid, in the bottom quickly reduced to the basis, it is frequent with ears, on edge with infrequent cilia. Threads of stamens are attached near the middle of a tube and from the basis or a little above throughout 1-1. 25 mm are very densely trimmed circle the lengthiest hairs. From five stamens, 2–3 are equal to a nimbus, the others are a little shorter than it. The column is a little longer than stamens. Fruit - berry red, oblong and ovoid, blunt or sharp, 8-18 mm long, 5 10 mm wide. The natural area of growth of a look is limited to areas of Central China (3, 12, 13).

The growth and development of this plant in Uzbekistan have not been studied, and there is no information in the literature. Therefore, our study aimed at studying the individual development that is, the study of growth and development in ontogenesis.

Acclimatisation and the properties of species adaptation to new conditions are manifested in the early stages of plant ontogenesis.

Therefore, the study of the ontogenesis of *L. barbarum* is of theoretical and practical importance. Because the study of the plant in the early stages of ontogenesis makes it possible to think about its subsequent growth and development. Any plant undergoes a series of morphological, anatomical, physiological and biochemical changes in ontogenesis (14).

Materials and Methods

The experiments were carried out in 2012 - 2019 in the laboratory and on the experimental site (39°38'54.6'' N and 66°57'56''.5'' E) of Samarkand State University.

When isolating age-related states, the methodological developments (13, 15). The features of ontogenesis were studied as per standard procedure (13) (Table 1).

Morphological characteristics of the plant in ontogenesis were studied on the basis of 10 model specimens (15). In the latent period, changes from seed ripening to seed germination were studied.

In laboratory, to determine seed germination, four samples of 100 seeds were taken, then placed in ordinary containers lined with wet filter paper. Seeds were placed in a thermostat with different temperatures (10 - 35 ° C) for germination for 30 days (16).

In the pre-reproductive period, germination of the sprouts was studied, the shape and size of the cotyledons, their vitality and also the shape and size of real leaves were noted.

In the reproductive period of the plant, the flowering cycle, the number of flowers, the duration of flowering and fruit ripening, ripening time and quantitative change were studied.

Table 1. Ontogenetic periods and age states of plants (15, 17)

Sl. No.	Ontogenetic period	Age state	Symbol
I	Latent	Seed	se
II	Pre-reproductive*	Seedling	pl
		Juvenile	j
		Immature	im
		Virginile	v
III	Reproductive	Young	g_1
		Mature	g_2
		Old	g_3
IV	Post –reproductive	Subsenile	ss
		Senile	s

*A more exact translation of the Russian terms would be pre-generative, generative and post-generative

Results and Discussion

Individual growth and development of *L. barbarum* can be divided into the following periods.

Latent period: This period of germination is determined by the formation of fertilised seeds as well as by the physiological processes occurring in them. At this time, the nutrients necessary for plant growth accumulate in thick and fatty seeds as they germinate. Goji seeds are kidney-shaped 2-2.5 mm long and 1-1.2 mm wide. Outwardly they are covered with a thin yellowish crust. The average weight of 1000 seeds is 1.1-1.2 gm.

Favorable temperature is a prerequisite for seed germination (Fig. 1. A). The optimum temperature for seed germination depends on the living conditions of the species. The most optimal seed germination temperature of *L. barbarum* was 20 °C and the germination of seeds were 74% (Table 2).

Temperature fluctuations during the day also affected seed germination. For example, at 25–30 °C the seeds germinated within 5-10 days, and at a low temperature (10–15 °C) seed germination occurred for 15-20 or more days. At high temperature, the seeds developed rapidly, but as a result of the uneven physiological process of the embryo, underdeveloped seeds died. This has led to low seed germination.

Pre-reproductive period. This period of *L. barbarum* includes a time interval from germination to the formation of the first flower. It was determined that the pre-reproductive period lasts 1-2 years (Fig. 1 B-E).

In this period of plant development, the following stages of development can be distinguished: seedlings, juvenile, immature, virginile plant. The state of germination is characterised by the fact that the soil is surface and carries cotyledons to the surface. Goji seedlings include the time from seed germination to the appearance of true leaves.

The optimal sowing date for goji is March. Seeds germinate within 5-8 days, and some even later. The length of the hypocotyl is on average 6-7 mm (Table 3). Germination of *L. barbarum* seeds begins with the appearance of the main root. Before the destroyed part of the seed, young roots grow outward and grow towards the inside of the soil. When this root reaches a depth of 0.4-0.6 cm, the hypocotyl raises the leaves

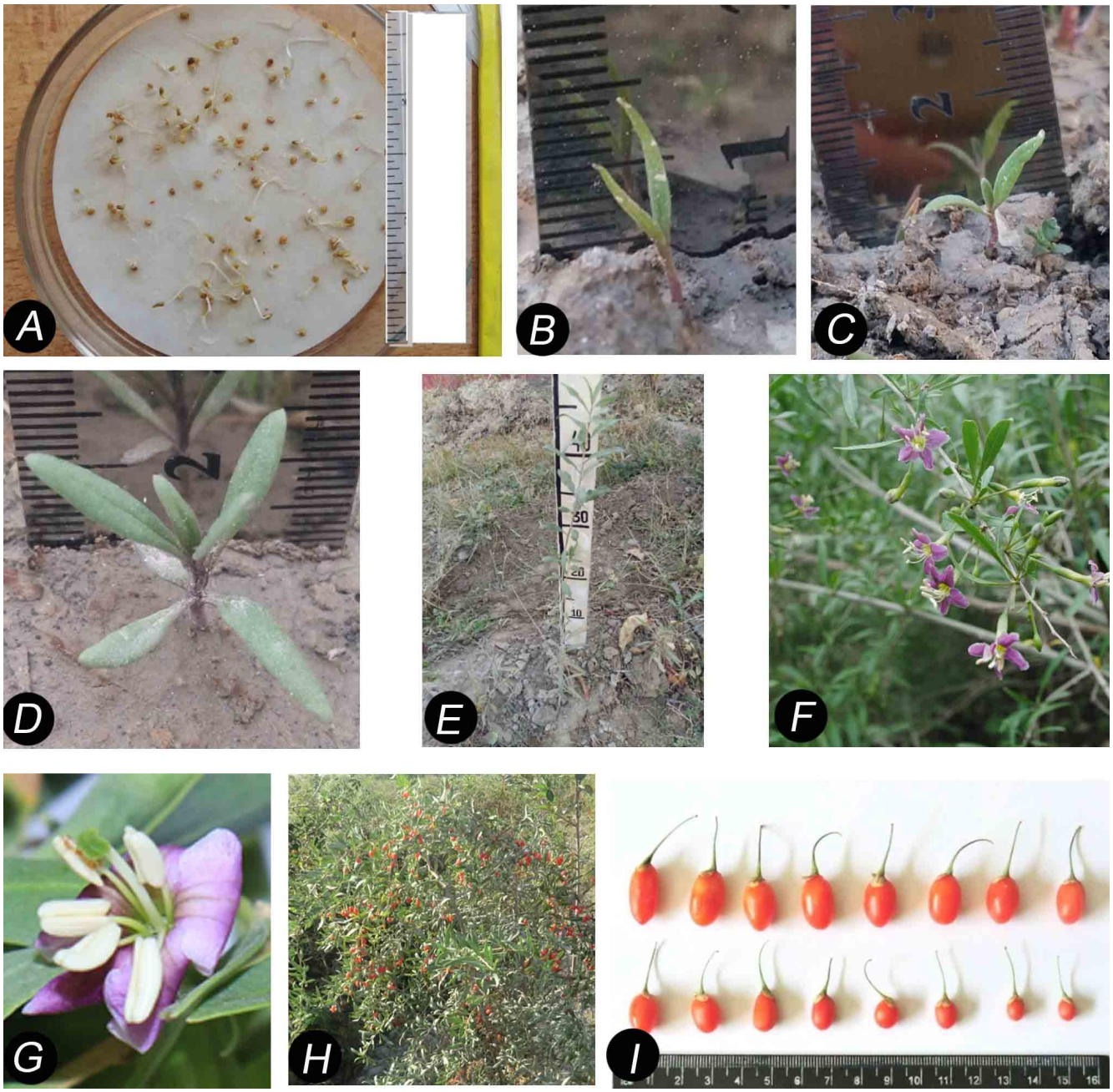

Fig. 1. General view of *L. barbarum* from seed germination to the generative period.
A – sprouted seeds; **B** – sprout; **C, D**– sprouts in the juvenile period; **E** – sprouts in the immature period; **F, G** – general view of the plant's flowers; **H,I** – general view of the fruit;

Table 2. The effect of temperature on the germination of *L. barbarum* seeds

Temperature ° C	The number of seeds sown	Germination by day%					
		5th day	10th day	15th day	20th day	25th day	30th day
10	100	-	-	6	4	2	-
15	100	12	18	7	3	2	-
20	100	22	30	14	5	3	-
25	100	28	32	6	2	-	-
30	100	32	28	4	-	-	-
35	100	37	22	1	-	-	-

of the seeds to the surface. The seed peel may appear on the surface of the soil along with the leaves of the seeds, and sometimes remain in the soil. The hypocotyl is light brown. The cotyledons are filiform, light green, smooth.

Juvenile plants. Plants enter the juvenile stage of development when the first true leaves appear. Escape to this time up to 0.9 cm high, with a distinct epicotyl and the first true internode. Leaf germination begins 7–11 days after germination. In

plants on the experimental field, each petal of the stem appears after 4-5 days. The cotyledons increase in size until they fall. The immature state begins on average after 45-65 days.

At this time, the average height of the sprout was 10-20 cm and is characterized by the absence of seed leaves. The annual goji sprouts in June and July; show the appearance of branches. However, this is not always the case. Branching occurs from the buds of the lower part of the plant, also second-order branches develop from 1 to 4. The height of the stems at the end of the growing season reaches 20–40 cm, and the number of internodes were 10–15.

Table 3. Measurement results of *L. barbarum* before the appearance of the third sheet pairs

Measurement time	Cotyledon size ($\bar{x} \pm S.E.$)	
	Length (mm)	Length (mm)
When germinating	6.0±0.2	1.6±0.1
When forming the first pair of leaves	8.4±0.2	2.4±0.1
When forming the second pair of leaves	9.1±0.2	3.1±0.1
When forming the third pair of leaves	10.2±0.3	3.8±0.1

An virginile plant reaches 50-75 cm in length. The root system is specialised and the main root has a length of 30-45 cm at the end of the growing season.

The reproductive period of the plant begins at the age of 2-3 years (Fig. 1 F, G). In young reproductive plants, two types of branches were observed: vegetative and specialized generative branches. In this state, the height of the plant on soil surface was 90-105 cm, and the root base was 2.4-3.0 cm. In the first year of the generative period, the plant blooms in the third decade of June. Generative branches develop in the upper part of the main stem. In the first year of the generative period, branches develop to the third order.

Mature reproductive plants individuals were characterized by maximum fruiting, an increase in the overall size of plants. The number of flowers on one generative shoot was from 6 to 47. The height of the generative shoots was 1-1.2 m.

The average leaf length was 5.25 cm and a width of 1.35 cm. The leaf mass was 0.45-0.55 gm. The leaves on the generative branch were small, thinner in shape than the leaves in the vegetative branch. On vegetative branches oval-shaped leaves were large.

We also observed a partial loss of vegetative leaves below the stem. Plants also have autumn leaves that are small, and some leaves are dull and light green; they are different from spring leaves. In Uzbekistan, the flowering of *L. barbarum* begins in April and ends in October. The fruits ripen from May to November (Fig. 1 H, I). Goji fruits were multi-seeded berries. Ours was discovered three forms of goji fruit: round, oval and cylindrical. Most fruits in the experimental plots comprise 49.8% of cylindrical fruits and 31.6% of oval fruits and 18.6% round fruits are relatively smaller. Fruits have seasonal variability.

Morphometric measurements showed that goji berries were not uniform.

The fruits collected in the spring were large, and the weight of the fruit and the size of the seeds increase accordingly. In the summer, especially in July and August, the sizes of the fruits were significantly reduced. In autumn, the sizes of the fruits were increased. But fertility drops sharply. The number of fruits in the branches was about 25-30 in the spring and 4-8 in the fall.

We have not yet fully studied the anterior reproductive stage and the post-reproductive stage of the plant. Our research is ongoing.

Conclusion

Our research was aimed at studying the growth and development of *L. barbarum* in Uzbekistan. Based on the experiments, it was determined that the optimum temperature for seed germination of *L. barbarum* was 20 ˚C.

The duration of the Pre-reproductive period of the plant is 1-2 years, the branching of seedlings begins in the month of June of the first year of vegetation, and in some seedlings it begins in the March of the second year of vegetation. The reproductive period begins with 2-3 years of vegetation. Flowering of plants occur in the months

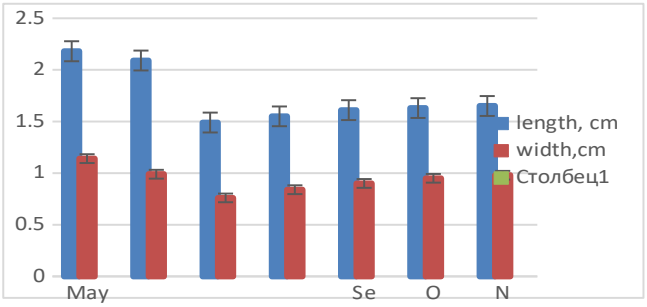

Fig. 2. The size of the fruits of *L. barbarum.*

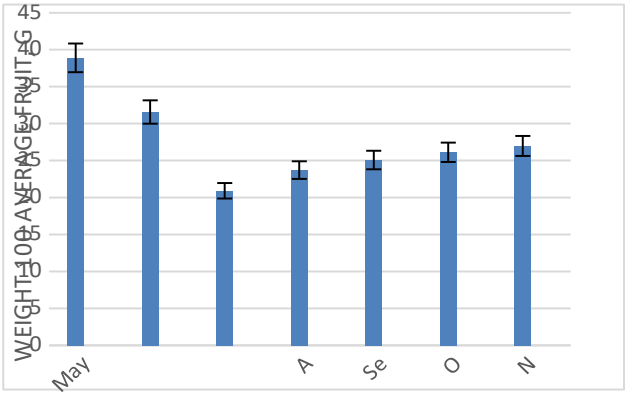

Fig 3. The weight of the fruits of *L. barbarum.*

of April - October, and fruit ripening in May - November.

In conclusion, the best time to plant *L. barbarum* in Uzbekistan is March, when 5-6 year old plants mature to full harvest. The largest fruits can be harvested in May.

Authors' contributions

NN designed the experiments and wrote the manuscript. KhH and ZU interpreted the data and corrected the manuscript. DS performed analysis. All authors have read and approved the paper.

Conflict of interests

Author has no conflict of interest to declare.

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