Efficiency of growing jujube (*Ziziphus jujuba* Mill) varieties that imported from China

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Abstract. Jujube (*Ziziphus jujuba* Mill) holds a prominent position within the spectrum of tree species in Uzbekistan, primarily due to its noteworthy nutritional and medicinal attributes. With approximately 400 distinct varieties having been developed in China, the task of introducing those best suited to our local conditions is of utmost importance. This article is dedicated to the presentation of outcomes arising from the cultivation of seedlings belonging to ten imported varieties from China, facilitated through the technique of clef grafting. In the grafting process, it is recommended to employ rootstocks and scions featuring an average diameter of no less than 20.0 mm, while the discrepancy between them should not exceed 0.9 mm. Following this approach, a notable increase in grafting efficiency up to 68.8% can be achieved, concurrently contributing to the attainment of seedlings with an elevated stature, reaching up to 143.5 cm. The findings underscore the significance of meticulous grafting methodology in optimizing the success rate of introducing diverse jujube varieties. This contributes to the enrichment of the horticultural landscape, fostering the cultivation of jujube specimens that can flourish effectively in the unique Uzbekistani conditions.
Keywords. *Ziziphus jujuba*, jujube, grafting, seedling, horticulture.

1 Introduction

Climate change and population growth in recent years require to introduce in all countries of varieties of medicinal plants that are resistant to external factors, as well as having food value. According to the FAO, 44% of the world's orchards account for the share of plants introduced [1].

Today, in the world of fruit growing, special attention is paid to the cultivation of jujube seedlings, gardening and increasing the gross yield. In particular, to date, the total area of orchards in the subtropical fruit group is 410,000 hectares, with a total yield of 7.5 million tons. Jujube is grown in large quantities in countries such as China, India, South Korea, Afghanistan, Pakistan, the United States and Russia. In China, intensive jujube orchards have been established on more than 200,000 hectares [2, 3].

Today there are more than 400 varieties of this crop in China, its plantings occupy an area of 200 thousand hectares and are the third largest after apple and citrus orchards.

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Ziziphus as a useful drought-resistant plant is grown in India, Pakistan, Afghanistan, Algeria, Israel, Egypt and the Caucasus countries. In recent decades, more and more attention has been paid to this plant in the USA, Italy, Spain and France [4].

Jujube or Chinese date (Ziziphus jujuba Mill.). It is one of the oldest main fruit trees in China. This plant was cultivated in China 4,000 years ago and created large varieties of edible local fruits [5].

Jujube varieties in China and methods of growing them in cultural conditions were studied by A.S. Koverga during a scientific expedition to China. According to him, jujube is widespread in the mountainous regions of China, especially in northern China. In China, mainly varieties and forms of one species - common Jujube (Ziziphus jujuba) are cultivated [6].

Jujube was named Ziziphus yuyuba in 1768 by the researcher Miller (Miller) on the basis of a tree that first spread in Southern Europe [7]. In Central Asia, the forms of the native jujube are mainly found in the arid subtropical region of southern Uzbekistan, Turkmenistan and Tajikistan, and are grown by amateur gardeners in their backyards. Samarkand Fruit Experimental Station In 1934, grafted jujube seedlings from California began to be grown locally [8].

Jujube - is widespread in Uzbekistan as a new, promising subtropical fruit tree. Jujube fruits are distinguished by high productivity, valuable nutritional feature, and medicinal properties. Jujube varieties are a fruit variety successfully introduced to our republic from China. In recent years, jujube has become increasingly popular as a new fruit species in the field of horticulture and medicinal plants in Uzbekistan. It is important to enrich the flora of Uzbekistan with new valuable fruit varieties and species, including the introduction of new Jujube varieties introduced from the Republic of China in the horticultural system of the our Republic. Cultural varieties and forms of folk selection of this fruit species are widely cultivated by the population in China as a valuable fruit tree [9].

In 1953, the Uzbek Research Institute of Horticulture, Viticulture and Wine-making was brought to the Samarkand Breeding Experimental Station as a test and began to grow jujube varieties created in China. As a result of many years of observations, promising varieties have been recommended for cultivation in Uzbekistan [10].

2 Materials and methods

The experimental work was carried out by the Extension center of Tashkent State Agrarian University. Promising varieties of Xiangzao, Zanhuangdazao, Tangzao, Mayazao, Junzao, Dabailing, Dongzao, Cuiwang Zao, Li Zao and Jixin Zao which are widely used in China, were whip grafted on rootstock grown from the seeds of the sour jujube (*Ziziphus acidojujuba*, *Ziziphus jujuba* Mill. var. spinosa) form of Jujube. Grafting was carried out in the last decades of March and the first decades of April. The following varieties were used in the research.

Shang jujube. The cultivar originated from Beixiang town in Yuncheng City of Shanxi Province. It is the dominant variety there and has a history of over 3 000 years. The medium-sized tree is half-spreading with a strong central leader trunk, dense branches and a semi round crown. The reddish-brown 1-year-old shoots are 30.0 cm long. The secondary branches are 25,3 cm long with less-developed thorns. The medium-sized column-shaped mother fruiting spurs can germinate 2~5 deciduous fruiting shoots. The small leaves are oval shaped and dark green. There are 48.1 flowers per deciduous fruiting shoot and 3.8 ones per inflorescence with a diameter of 6.8 mm for the zero-level flowers.

The large oval-shaped fruit weighs 19.1 g with irregular sizes. It has purplish-red thick skin and a rough surface. The greenish-white flesh is thick and hard, tight-textured, sweet, with little juice. Dried fruits have whippy flesh, tolerant to extrusion. It has an excellent

quality for dried fruits. The percentage of edible part of fresh fruit is 96.8%, and SSC, TTS, TA, Vc is 28.50%, 25.51%, 0.34 and 474.00 mg per 100 g fresh fruit. The content of flavones and c AMP in mature fruit skin is 2.95 mg/g and 101.97 ug/g. The percentage of fresh fruits which can be made into dried ones is 53.0%. And the content of TTS and TA is 70.29% and 0.82%. The small stone is spindle-shaped averaging 0.61 g.

Zhuanen jujube. The cultivar originated from Zanhuang County in Hebei Province. It is the dominant variety there with a history of over 400 years and a cell chromosome of 2n=3x=36.

The large tree is half-spreading with a medium-strong central leader trunk, sparse and strong branches and a conical-shaped crown. The yellowish-brown 1-year-old shoots are 83.0 cm long. There are 7~10 secondary branches. The large column-shaped mother fruiting spurs can germinate 3~4 deciduous fruiting shoots. The thick wide leaves are oval-shaped and dark green. There are 50 flowers per deciduous fruiting shoot.

The large fruit is column-shaped or nearly obovate, averaging 18.6 g. It has a smooth surface and medium- thick red skin. The thick flesh is nearly white, tight-textured, crisp, sweet and a little sour, with medium juice and a good quality for fresh-eating, processing dried fruits and candied fruits. The percentage of edible part of fresh fruit is 96.7%, and SSC, TTS, TA and Vc is 33.30%, *29.32%,* 0.78% and 324.70 mg per 100 g fresh fruit. The content of flavones and cAMP in mature fruit skin is 13.43 mg/g and 50.58 Ug/g. The percentage of fresh fruits which can be made into dried ones is 47.8%. The content of TTS and TA in dried fruit is 66.91% and 1.93%. Dried fruits have plump and whippy flesh, tolerant to storage and transport with a better than normal quality. The small spindle-shaped stone weighs 0.62 g.

Tong jujube. The cultivar originated from Mayang, Xupu, Huayuan in west Hunan Province and in Lingling, Hengshan, Guiyang, Qiyang in southern Hunan Province. It is the dominant variety in Xupu County.

The large tree is spreading with an irregular crown and pendulous external branches. The reddish-brown 1-year-old shoots are 75.3 cm long and 1.01 cm thick. The intemodes are 5.7 cm long with gray wax on the sun-side and developed thorns. The secondary branches are 29 cm long with 7 nodes of small curvature. The column-shaped mother fruiting spurs can germinate 4 deciduous Suiting shoots which are 24.3 cm long with 17 leaves. The small green leaves are oval-shaped. There are many medium sized flowers produced, averaging 6 ones per inflorescence. It blooms in the daytime.

The small oblate fruit has a vertical and cross diameter of 2.54 cm and 2.19 cm averaging 8.0 g. It has a flat-round shoulder, a shallow and wide stalk cavity, a flat fruit apex and medium-thick red skin. The light-green or white flesh is tight- textured and sweet with medium juice. It can be used for making dried fruits with medium quality. The percentage of edible part of fresh fruit is 93.1 %, and the content of TTS, TA and Vc is 25.05%, 0.44% and 403.33 mg per 100 g fresh fruit. The percentage of fresh fruits which can be made into dried ones is 34.0%, and the content of TTS in dried fruit is 63%. The medium-sized obovate stone weighs 0.55 g, and the percentage of containing kernels is 63.3 %.

Mya jujube. The cultivar originated from Beijing, with a long cultivation history. It is planted in different districts of Beijing with a large quantity.

The medium-sized tree is half-spreading with a round crown. The grayish-brown trunk bark has wide striped fissures, easily shelled off. The reddish-brown 1-year-old shoots are 84.7 cm long and 1.24 cm thick. The intemodes are 7.7 cm long with less wax. Most thorns are degrading, gradually falling off in 1 or 2 years. The secondary branches are 31.7 cm long with 6 nodes. Young mother fruiting spurs are conical-shaped and mature ones are column-shaped. The mother fruiting spurs can germinate 5 deciduous fruiting shoots which are 22.1 cm long with 13 leaves. The medium-sized leaves are oval-shaped with a

gradually-cuspate apex, a round or wide-cuneiform base and a sharp saw-tooth pattern on the margin. Each inflorescence has 5 flowers.

The medium-sized conical fruit has a vertical and cross diameter of 10.10 cm and 4.42 cm, averaging 10.1 g with irregular sizes. One side of the fruit is flat while the other fs half-moon-shaped. It has a flat and asymmetrical shoulder, a shallow and wide stalk cavity, a pointed-round fruit apex, a smooth surface and thin red skin. The light-green flesh is crisp, juicy, sour and sweet. It has an excellent quality for fresh-eating. The content of SSC, TTS, TA and Vc in fresh fruit is 31%, 27.91 %, 0.30% and 258.78 mg per 100 g fresh fruit. The content of flavones and cAMP in mature fruit skin is 12.27 mg/g and 8.70 Ug/g. The large spindle-shaped stone weighs 0.45 g.

Joou jujube. The cultivar originated from remote some mountains of Jiaocheng County in Shanxi Province. It is one of the ten famous jujubes in Shanxi Province with a history of over 1 000 years.

The large tree is half-spreading with a strong central leader trunk, strong and medium-dense branches and a natural-round crown. The reddish-brown 1-year-old shoots are 54.8 cm long. There are 6~7 permanent secondary branches with less developed or degraded thorns. The large conical-shaped mother fruiting spurs have a long life and can germinate 3—4 deciduous fruiting shoots, which are 15.0 cm long with 10 leaves. The large leaves are long oval-shaped and dark green. The number of flowers is medium large.

The large fruit is column-shaped in earlier growth stage and long obovate in later growth stage. It weighs 26.3 g with a regular size. The thick flesh is white or greenish white, loose-textured, crisp and sweet with medium juice and a good quality and wide applications. It can be used for fresh-eating, processing dried fruits, candied fruits and alcoholic fruits. The percentage of edible part of fresh fruit is 96.3%, and SSC, TTS, TA and Vc i s 33.00%, 28.68%, 0.45% and 430.20 mg per 100 g fresh fruit. The content of flavones and cAMP in mature fruit skin is 1.78 mg/g and 102.14 Ug/g. The percentage of fresh fruits which can be made into dried ones is 56.8%, and the content of TTS and TA in dried fruit is 71.77% and 1.58%. SSC, TTS and TA in alcoholic jujubes is 36.30%, 30.83% and 0.83%.

Debay jujube. The cultivar originated from Xiajin County in Shandong Province, and spreads in Linqing, Wucheng, Yanggu in Shandong and Xianxian County in Hebei Province. It is dispersedly planted.

The small tree has moderate vigor, spreading with a strong central leader trunk, medium-dense branches and an umbrella-shaped crown. The reddish-brown 1-year-old shoots have moderate growth vigor, 81.0 cm long with the intemodes of 8.0 cm. The secondary branches are 29.1 cm long with 6 nodes and less-developed thorns. The medium-sized mother fruiting spurs can germinate 3~4 deciduous fruiting shoot, which are 23.5 cm long with 16 leaves. The medium-sized leaves are oval-shaped and dark green. There are many small flowers with a diameter of 6 mm produced, averaging 10-11 ones per inflorescence.

The large fruit is nearly round, averaging 31 9 g with a regular size. It has a purplish-red thin skin and an unsmooth surface. The greenish-white thick flesh is loose-textured, Crisp and sweet, with medium juice and a good quality for fresh eating. The percentage of edible part of fresh fruit is 97.2%, and SSC, TTS, TA and Vc is 33.00%, 24.50%, 0.28% and 280.08 mg per 100 g fresh fruit. The small stone is spindle-shaped, averaging 0.9 g almost without kernels.

Doon jujube. The cultivar originated from and spreads in Huanghua, Yanshan in Hebei Province and Zhanhua, Zaozhuang in Shandong Province.

The tree is spreading with a semi-round crown, a strong central leader trunk and thin and dense branches. The grayish-green 1-year-old shoots are 57.4 cm long with the intemodes of 7.8 cm, with almost degraded thorns. There are 4~7 secondary branches on

each 1-year-old shoot. The small mother fruiting spurs can germinate 4.3 deciduous fruiting shoots. The medium sized leaves are oval-shaped. There are many small flowers with a diameter of 5.0-5.8 mm produced.

The small fruit is nearly round with a vertical and cross diameter of 3.10 cm and 2.80 cm, averaging 11.9 g with irregular sizes. It has thin red skin and a smooth surface. The delicate flesh is crisp and juicy, with a sweet taste and a very good quality for fresh-eating. The percentage of edible part of fresh fruit is 94.1%, and the soluble solid content (SSC), monosaccharide, disaccharide, total sugar (TTS) and Vitamin C (Vc) is 37.8%, 14.80%, 19.00%, 33.80% and 292.60 mg per 100 g fresh fruit. The content of flavones and c AMP in mature fruit skin is 25,59 mg/g and 94.91 Ug/g. The oval-shaped stone has a vertical and cross diameter of 1.70 cm and 0.70 cm, averaging 0.70 g with a short apex and medium-deep veins. The percentage of containing kernels is 86.7%. Most stones contain a well-developed kernel, which can be used as breeding material.

Lee jujube. The cultivar originated from Linyi and Yuncheng in Shanxi Province with a cultivation history of over 3 000 years.

The small tree is spreading with a weak central leader trunk and a round crown. The trunk bark has deep fissures, easily shelled off. The reddish-brown 1-year-old shoots have strong germination ability and moderate growth potential, averaging 83.1 cm long with 6~8 nodes. The secondary branches are 28.3 ctti long with less-developed thorns. The small conical mother fruiting spurs can germinate 4.4 deciduous fruiting shoots. The thick leaves are oval-shaped and dark green. The number of flowers is rather small, averaging 2.2 ones per inflorescence. The medium-sized blossoms have a diameter of 7.2 mm for the zero-level flowers.

The extremely large fruit is obovate pear-shaped, with a vertical and cross diameter of 4.50 cm and 4.00 cm, averaging 31.6 g with irregular sizes. It has light-red thin skin. The rough flesh is loose-textured, crisp, juicy and sweet. It has a very good quality for fresh eating. The percentage of edible part of fresh fruit is *96.6%,* and SSC, monosaccharide, disaccharide, TTS, titratable acid (TA) and Vc is 27.90 17.00 H, 5.25$), *22.25%, 0.31%* and 292.25 mg per 100 g fresh fruit. The content of flavones and cAMP in mature fruit skin is 3.91 mg/g and 122.17 ug/g. The small spindle-shaped stone weighs 1.08 g.

Jeshine jujube. The cultivar originated from Xinzheng, Zhongmou, Xihua and the suburbs of Zhengzhou City in Henan Province. It is mainly planted in Xinzheng which is the 2nd dominant variety there. There are still some trees of over 400 years old.

The medium-sized tree is half-spreading with a round crown. The yellowish-brown 1-year-old shoots are 88.2 cm long and 1.22 cm thick, with the intemodes of 6.3 cm. The secondary branches are long, averaging 34.6 cm with 6 nodes of a small curvature and less-developed thorns of 1.2 cm long. The mother fruiting spurs are small and column-shaped. The deciduous fruiting shoots are 23.5 cm long with 14 leaves. The large green leaves are oval-shaped. There are many large flowers with a diameter of 7.6 mm produced. It blooms in the daytime.

The small fruit is chicken-heart-shaped or oval-shaped, averaging 4.9 g with a regular size. It has purplish- red thin skin and a smooth surface. The greenish-white flesh is medium thick and tight-textured, crisp and sweet, with less juice and a good quality for dried fruits. The percentage of edible part of fresh fruit is 93.8%, and SSC, TTS, TA and Vc is 37.20%, 32.68%, 0.70% and 488.90 mg per 100 g fresh fruit. Dried fruits have tight-textured and whippy flesh with strong tolerance to extrusion, storage and transport. The large stone is spindle shaped, averaging 0.48 g.

3 Results and discussion

This research was carried out by grafting 10 prospective varieties on seedlings grown from seeds of the wild offspring form Jujube that imported from China. These varieties are valuable in terms of fruit size, taste, color, appearance, exportability and composition. Grafting was carried out in the spring, and at the end of the growing season, the degree of retention of grafts, diameters of rootstocks and scions, as well as the height indicators of the grafted seedlings were determined.

Grafting regulations require that the rootstocks and scions be matched to each other in terms of dimensions. Especially, it is very important that their diameters match during the cleft grafting process. The diameter of the seedling used as a graft in the grafting process affected its retention in our research, too. In the research, scions were used that the average diameters were 11.7-20.0 mm. Accordingly, grafting work was carried out to the seedlings the sort of Shang jujube with 17.0 mm, Zhuanen jujube with 18.9 mm, Tong jujube with 15.3 mm, Mya jujube with 14.5 mm, Joou jujube with 20.8 mm, Debay jujube with 16.2 mm, with Dooon jujube 15.5 mm, Cuiwan jujube with 14.8 mm, Lee jujube with 16.9 mm and Jeshine jujube with 12.6 mm in diameter. During the grafting, dimensions of the scions differed from the dimensions of the rootstocks by an average of 0.1-3.2 mm. This allowed the grafting work to be carried out efficiently (Figure 1).

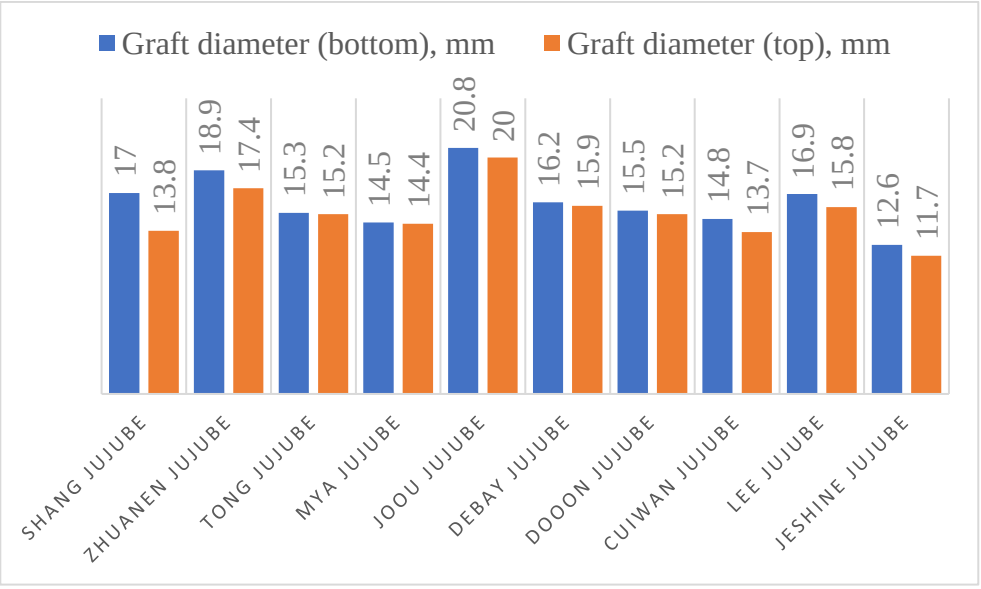

Figure 1. Dimension of rootstocks and scions in the method of cleft grafting.

The efficiency of grafting by sorts, that is the retention rate was 45.2-75%. The difference in the size of the rootstocks and scions used in grafing was 0.1-0.3 mm (Tong jujube, Debay jujube, Mya jujube ва Dooon jujube), the efficiency was low (45.2-51.5%) compared to other varieties. This difference was higher rate (68.8-75.0%) in varieties with 0.8–0.9 (Cuiwan jujube, Joou jujube and Jeshine jujube). This figure was equal to 59.9-65.8% in varieties with a difference of more than 1.0 (Lee jujube, Shang jujube and Zhuanen jujube). The indicator of the Jeshine jujube sort was 75%, while the Tong jujube was 45.2%. Compared with other varieties, we can observe that the grafting efficiency of this variety is 1.09-1.65 times higher (Figure 2).

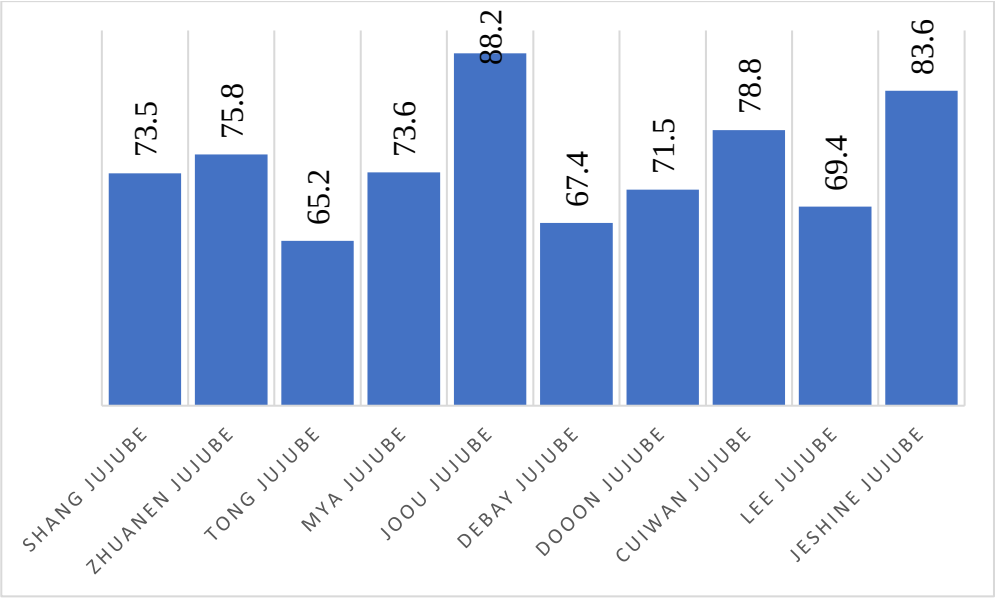

Figure 2. Retention rate of the sorts which was graft by the method of cleft grafting, %.

When the growth rates of grafted seedlings were studied, their height was equal to 82.1-143.5 cm. The highest value was observed in the Joou jujube (143.5 ± 3.50) and the lowest in the Jeshine jujube (82.1 ± 6.12) (Figure 3).

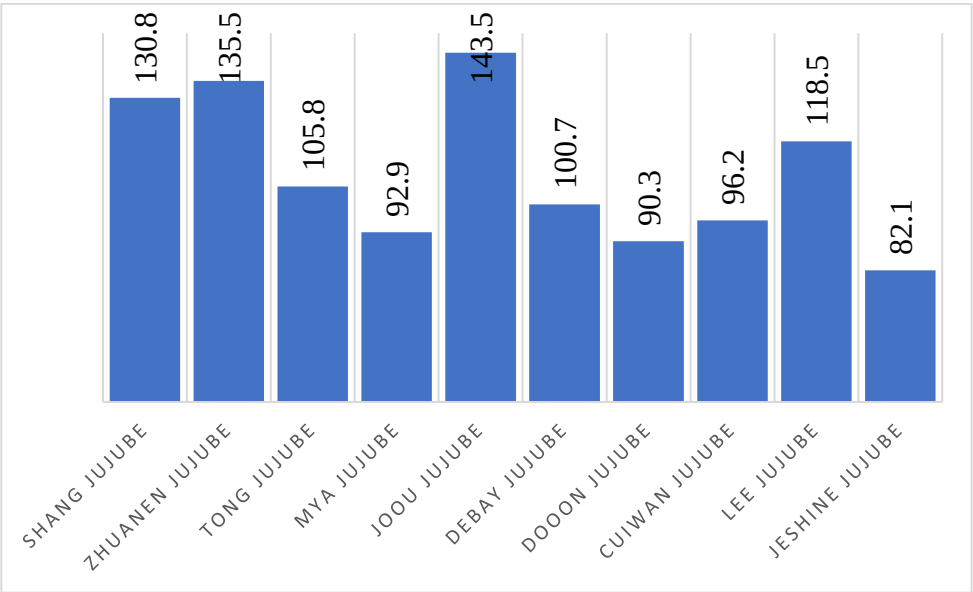

Figure 3. Height of grafted seedlings, cm.

4 Conclusions

In our research, it has been found that the role of the rootstocks and scions' diameters in the cultivation of grafted seedlings of Jujube is very important. Grafting efficiency and seedling growth rates have been also found to be good when the difference between them was 0.8-0.9 mm. In our research, the grafting efficiency of a 20.0 mm scion to a rootstock with an average diameter of 20.8 mm has been 68.8%. This ensures that the dimensions of rootstock and scions in the cultivation of Jujube seedlings are not more than 20 mm, and the difference between them does not exceed 0.8, the growth rate of seedlings reaches 143.5 cm.

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