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Study of Growth Rate and Yield Performance of Five Cultivars of Gorgak Melons (*Cucumis melo* L.) using Morphological Traits in Sar-e-Pol Province, Afghanistan

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ABSTRACT

Background: Melon (*Cucumis melo* L.) is the genetically most diverse and the economically most important species of the genus *Cucumis* grown around the globe. The species occupies the third world rank of production quantity. Melons demonstrate high morphological and phonological polymorphisms in a flower type and leaf shape, plant growth habits, and fruits morphology traits i.e., fruit size, fruit shape, fruit texture, fruit color, and fruit flavor. The Afghani melon has a great reputation in local and regional markets and meets the majority of consumers desires. In Sar-e Pol province of Afghanistan, a particular of melon, the Gorgak melons, are widely grown for commercial purposes. The cultivation of the Gorgaks in dry and semi-dry regions has a better production by high quality and quantity.

Materials and Methods: The experiment was carried out in Gangalbagh Research Station of Sar-e Pol province employing a Randomized Complete Block Design (RCBD) with two replications.

Findings: Gorgak cultivars demonstrated the highest morphological, growth and yield diversity, mainly for fruit traits. The diversity may be attributing mostly to positive or negative selection. Based on observation it is known that the stem color (RHS 143B), number of mean stem, number of lateral stems, stem length, bio products, germination percentage and 50 % germination there were no significant differences between cultivars. Gorgak safeed derived stem color characters from Gorgak seya and Gorgak sabz derived from Gorgak ablaq. Adjacent ranges can undergo shifts, in color due to factors, such as fluctuations, in light intensity or the absence of specific nutrients.

Conclusion: Gorgaks have different phenotypic characters from each other on different morphological characters. Gorgak seya, Gorgak sabz and Gorgak ablaq exhibits diversity with its characters displaying a remarkable level of stability.

Keywords: *Cucumic melo* L., Gorgak, Morphological traits, Growth, Diversity, Sar-e-Pol

INTRODUCTION

Melon (*Cucumis melo* L.; 2n = 2x = 24) that-belongs to Cucurbitaceae family is the most economically important, and genetically diverse species of the genus *Cucumis* grown around the globe. The genetic variability of this species is reflected at the morphological, and biochemical levels (Akashi et al., 2002; Mliki et al., 2001; Lija and Beeby, 2021; Nyirahabimana and Solmaz, 2021; Liu, 2008). The first origin of the melon species is Africa with having different chromosome number (2n = 12) (Kerge and Gum, 2000; Tanaka et al, 2013). However, the second proposed origin for this species are Afghanistan, Turky, Iran, India, Turkmanistan,

Tagikistan, Ozbekistan, China, Koreya, Spain and Portagal (El-Tahir et al., 2004). The melon plant is characterized by its large leaves, long petioles, simple tendrils, long branches covered in hair and either climbing or trailing growth habits. *Cucumis melo* is known as a having high polymorphic species and this characteristic hold significant value in taxonomic studies (Bezirganoglu, 2018). Nutritional claims that daily consumption of melon has health benefits such as reducing the risk of stroke, lowering cholesterol levels and providing energy. Fruit quality of melon is influenced by several factors, including varieties, aeration, fertilizers, temperature and so on (Tang et al., 2012).

Melon ranks the third place in the world quantity production (FAO, 2018). It is one of the most important export products of our country. Cultivation of this plant dates back to the ancient times in the southern and northern province of the country. The melon is an annual plant with sweet, tasty fruits containing over 93 % water and small amount of carbohydrates, vitamins and minerals, the melon fruits are eaten both fresh and dry. Among all melon species, Afghani melon is highly reputed in both local and regional markets meeting consumers' preferences and demands. Melon production has attracted the attention of fruit traders and producers; it is a high-yielding plant with an average production of of 2500 Kg/acre in the southern and northern regions. Furthermore, the price per kg of melon in 2023 at the time of harvest was 20 Afghani, which amounts to 50000 Afghanis per acre of melons.

In Sar-e Pol province of Afghanistan, Grogak melons are the most important and the most famous ones for commercial production. The cultivation of Gorgaks in arid and semi-arid regions could result in better quality and maybe higher quantity. Melons have high diversity and polymorphism in their leaf shape, flower sex, plant habits and fruit morphology for their shape, color of mesocarp, flavor, skin color and texture. These traits contribute to variations in size, shape, texture, color and flavor of the fruit. When looking at characteristics like fruit weight, number of flowers, days to germination and days to flowering we observe a range of variation. This means that these traits can be effectively used in selecting for improvement. Fruit diameter is positively and highly correlated with fruit yield. Therefore focusing on this trait during selection could potentially enhance yield. There is a negative correlation between days to flowering and fruit yield and by selecting accessions, with fewer days to flowering periods it may be possible to improve fruit yield (Bartaula et al., 2019).

According to a study, by Saberi et al. (2006) they found a variation in factors such, as fruit yield, fruit number and fruit length which greatly impacted the final yield. Studying the characteristics of melon phenotypes is important because this crop exhibits a range of variations. In the same direction, internal color of the flesh is also worth mentioning. Several previous research on muskmelons (*C. melo* L.) has indicated that traits such as netting and flesh color are inherited monogenitically (Pitrat., 2017). The white, green and orange colors found in melon fruit flesh are a result of a combination of chlorophyll and carotenoid pigments (Burger et al., 2010). The major accumulated carotenoids in orange-flesh cultivars of melon are β–carotene (Nunez-Palenius et al., 2008). Quantitative differences in β–carotene caused the most variation in color density (Burger et al., 2010). There is lack of information on the genetic variations in Gorgak melons in Afghanistan. The main objective of this study was to illustrate the morphological, growth and yield diversity of 5 Gorgak melons (*C. melo* L.) in Sar-Pol province, Afghanistan.

MATERIALS AND METHODS

In order to study the morphological, growth and yield diversity of gorgak melon cultivars, in Sar e Pol province, seed of five native cultivars of melon which include: Gorgak seya, Gorgak safeed, Grogak sabz, kok

Gorgak and Gorgak ablaq were collected from Sar-e Pol province (Fig. 1). This study was conducted from 14 march to 24 June 2023, at the Research Station of faculty of Agriculture, Jangalbagh Research station of Sar-e Pol province, (36˚ 15` 24″N and 65˚ 55` 82″ E, 593 meters asl). The soil has loam- clay texture, and has been left two years without cultivation. In the first stage, the research land was deep plowed with three-furrow and in second time plowed with nine-furrow cultivator.

The experiments were laid out in a Randomized Complete Block Design (RCBD) with tow replications. The size of each plot for one treatment was 2.5 m width and 4.2 m length, total space for one plot was 10.5 m^2. There was one furrow in all, it had 21 m long and 1 m wide and 50 cm depth and crop was sown continually on the both sides of each furrow row to row and plant to plant distance 2 m and 60 cm, respectively. After preparing land we made 40*30 cm pits and mix the soil with 400 gr animal manure and soil were prepared for plastic mulch. There were 30 plant and 5 treatments in each replication. According to its characteristics, Sar e Pol province has semi-arid region climate. Summer was dry, average of rainfall was 440.5 mm, snow fall 45 cm and the highest temperature was 40 C˚ and lowest temperature was -10 C˚ (personal communication, Irrigation & livestock of Sar-e Pol province, 2023; A). Measurements of morphological, growth and yield diversity characters were based on four randomly selected plants in each treatment. When needed the pesticide and insecticide were applied. Weeds were removed according to the necessity.

After the soil moisture reaches the capacity stage of the field, planting of seed that were wetted 12 hours before at 20 C˚ temperature, are created with specific distances 3 cm pits and covered with soft soil. Thinning was done 20 days after germination and only one plant that was healthy, strong, without diseases and pests and had regular growth, was remain. Irrigation was done in a furrow form and its frequency was determined according to the dryness of the soil, the nature of the wind, the stages of plant growth, evaporation and transpiration (Table 1). Four fruits were left in each plant and the rest were removed. After full physiological and horticultural ripening, the fruit was collected at different intervals (Table 1).

The fruits were weighted with a digital electric balance and the results were estimated per square meter. Parameters such as mesocarp diameter, fruit length and width, seed area diameter, seed area length, stem length, leaf length and width was measured with meters, skin smoothness and roughness, fruit color, fruit mesocarp color, and its smell was measured subjectively and objectively. The Total Soluble Solid (TSS, Brix) were measured by ATC portable digital refractometer 0-40 %.Seeds are collected in disposal plastic cup, which had the name of the same type of cultivar written on the back of the cup. After 4-6 days, when the seeds the surrounding debris, it was washed and placed on disposal plates with the name of the cultivar written on it were placed to dry. After drying, the seeds were sorted and separated in to standard and non-standard ones, and the weight of 100 eggs weighed by digital 500 model of 500 gr balance. Data analysis was done using biometric methods with 5 % probability.

RESULTS AND DISCUSSION

Gorgak cultivars exhibited a high morphological, growth and yield diversity, manly for fruit traits. It may be mostly positive or negative selection. Many traits have a Mendelian inheritance and studying their genetic control can be done using F1, F2 and back cross progenies. However, for quantitative traits like sugar content, fruit shape, disease resistance, weight, earliness it is more effective to use "immortalized" genotypes such as doubled haploid lines or recombinant inbred lines (Dogimont, 2010–2011).

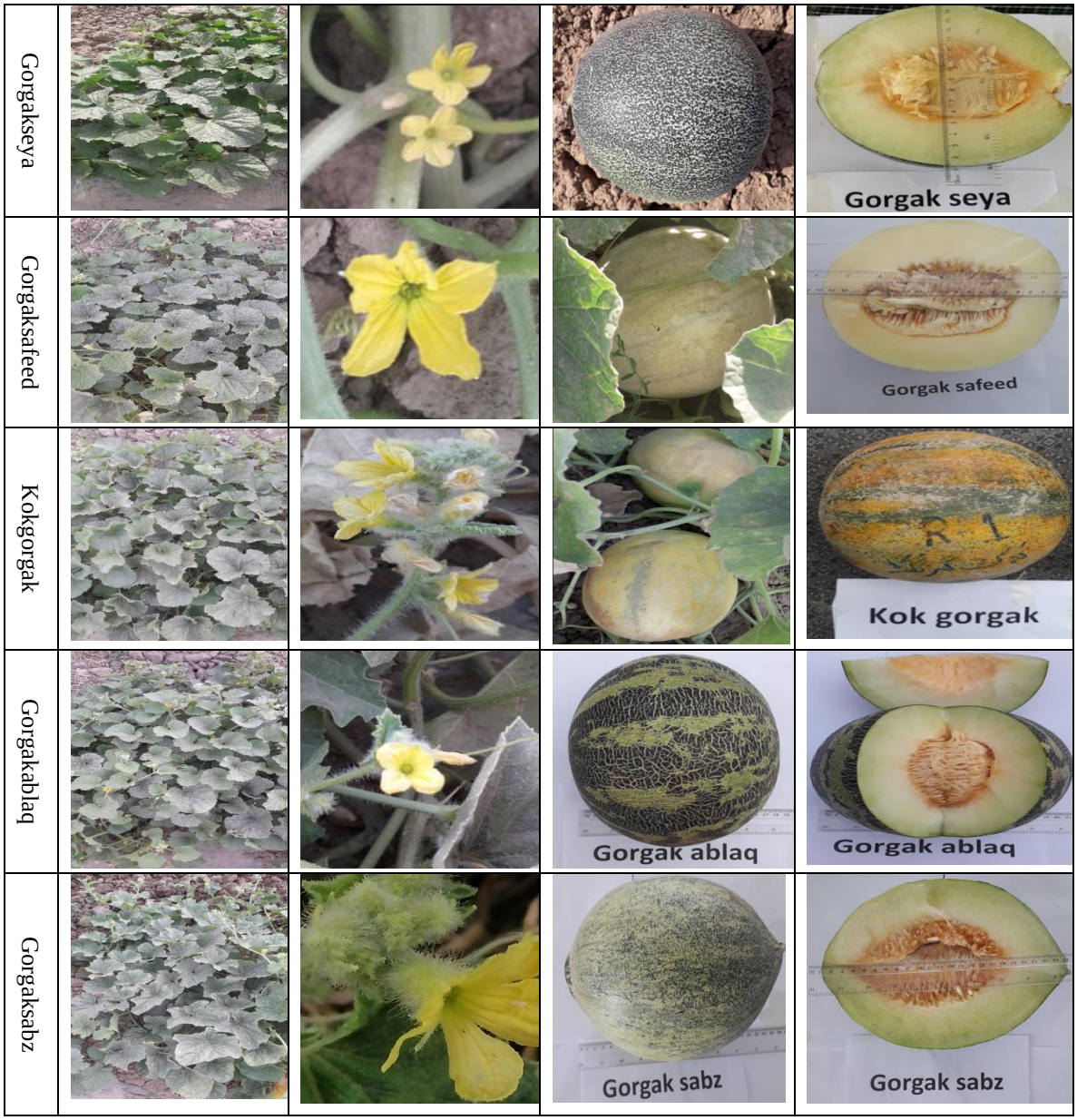

Figure 1. Morphology of different part of Gorgak melons

Table 1. Irrigation details and harvest			
Irrigation		Harvesting	
Number of irrigation	Date of irrigation	Number of harvesting	Date of harvesting
1	14-Mar-2023	1	6-Jun-2023
2	2-Apr-2023	2	11-Jun-2023
3	16-Apr-2023	3	18-Jun-2023
4	2-May-2023	4	24-Jun-2023
5	12-May-2023		
6	5-Jun-2023		

It's important to note that characteristics related to stems, leaves, flowers, fruits and seeds can undergo changes between generations. These changes can occur due to mutations or environmental influences because phenotypic traits are influenced by both expression and environmental factors (Maryanto, 2013). According to

the observations it is obvious that the stem color (RHS 143B), number of main stem, number of lateral stem, stem length, bio products, germination percentage and 50 % germination there were no significant differences between cultivars (Table 2). Gorgak safeed derived stem color characters from Gorgak seya and Gorgak sabz derived from Goragak ablaq. Adjacent ranges can undergo shifts, in color due to factors, such as fluctuations, in light intensity or the absence of specific nutrients (Nugroho et al, 2019).

Table 2. Characteristics depend to stem gorgak melons cultivars studed in the current research.

Phenotypic character	Cultivars				
	Gorgakseya	Gorgaksafeed	Gorgaksabz	Kokgrogak	Gorgakablaq
stem color	RHS 143B	RHS 143B	RHS 143B	RHS 143B	RHS 143B
Number of mean stem	7a ±3	6b ±4	7a ±2	5c ±2	6b ±4
Number of lateral Stem	21a ±4	12d ±2	14c ±3	21a ±5	16b ±3
Stem length (cm)	2.45a ± 0.58	1.86b ± 0.42	1.95b ±0.23	1.78b ±0.02	1.83b ±0.06
Bio-Products (kg)	3.42a	1.67b	1.89b	0.5c	2.92a
Germination %	95a	95a	95a	90b	95a
Days to 50 % germination	4a	4a	4a	3b	5a

Means followed by different letters in each row are significantly different at 5% probability level.
n.s, not significant at given probability level.

Characteristics depends to leaf according on observations, leaf shape (triangular), leaf color (RHS 139B), there were no significant differences between those cultivars (Table 3). Adjacent ranges can undergo shifts, in color due to factors, such as fluctuations, in light intensity or the absence of specific nutrients (Nugroho et al, 2019). But between leaf lengths, leaf width and leaf area significant.

Table 3. Characteristics depend to leaf gorgak melon cultivars studded in the current research.

No	Phenotypic character	Cultivars				
		Gorgakseya	Gorgaksafeed	Gorgaksabz	Kokgrogak	Gorgakablaq
1	Leaf shape	Triangular	Triangular	Triangular	Triangular	Triangular
2	leaf color	RHS 139B	RHS 139B	RHS 139B	RHS 139B	RHS 139B
3	Flower shape	Rotate	Rotate	Rotate	Rotate	Rotate
4	Leaf length (cm)	13.4a ±6	11.5b ±4	13a ±6	11.6b ±6	10.3 c ±6
5	Leaf width (cm)	17.9a ±8	17.6a ±8	16b ±6	14.4d ±7	15.5c ±5
6	Leaf area (cm^2)	169b	159.5c	165b	170.5b	203a

Means followed by different letters in each row are significantly different at 5% probability level.

Depend to characteristics of flower melon cultivars, were differences at days to 50 % flowering and flowering age of each cultivar, the variation in genetics and the levels of flowering hormones can be attributed to factors, including the intensity of light and temperature that a plant is exposed to. Pruning plants is a known technique that encourages flower growth by preventing the development of branches ultimately leading to more photosynthesis and better flower formation. Additionally, the process of flowering is greatly affected by fluctuations, in flowering hormones (Budiyanto et al, 2010). Gorgak melons are an andromonoecious plant, so it has male and hermaphrodite flowers. Most melons are andromonoecious plants (Kounon et al, 2009). Andromonoecious plants have evolved as a means of pollination and represent one of the evolutionary adaptations seen in modern flowers (Table 4).

Table 4. Characteristics depends to flower gorgak melon cultivars studded in the current research						
No	Phenotypic character	Cultivars				
		Gorgakseya	Gorgaksafeed	Gorgaksabz	Kokgrogak	Gorgakablaq
1	Gender expression	Andromonocious	Andromonocious	Andromonocious	Andromonocious	Andromonocious
2	Flower shape	Rotate	Rotate	Rotate	Rotate	Rotate
3	Stamen color	RHS 7B	RHS 7B	RHS 7B	RHS 7B	RHS 7B
4	Pistil color	RHS 7B	RHS 7B	RHS 7B	RHS 7B	RHS 7B
5	Days to 50 % flowering	39a	37ab	35bc	34c	35bc
Means followed by different letters in each row are significantly different at 5% probability level.						

According characteristics depends to fruits known that all cultivars skin characteristics are Reticulate. Gorkag ablaq horticulture maturity is 85 days the most early maturing, and Gorgak safeed is 91 days to horticulture maturity. Fruit types in Gorgak seya, Kok gorgak and Gorgak ablaq are melon with aromatic fruit character. Gorgak safeed and Gorgak sabz are non-aromatic fruit characters (Figure 2). Between all cultivars Gorgak safeed is globular according to fruit shape others are ovate. The skin color of the Gorgak seya RHS202A + 202D and Gorgak ablaq RHS202A+135A close. The skin character of Gorgak seya, Gorgak sabz and Gorgak ablaq was significantly not different; this maybe because these cultivars are closer more than their parental relationship, but Gorgak safeed was significantly different (Table 5). The flesh color of Gorgak seya, Gorgak sabz and Gorgak ablaq is RHS140C and the more similar to Kok gorgak RHS142C. Cultivated melons can have flesh colors ranging from green (due, to the presence of chlorophyll) white (resulting from an allele wf) to orange (caused by the presence of β carotene with a dominant allele gf+). The shelf life of melons can be affected by factors, including storage temperature, humidity, exposure to sunlight and air circulation (Yusuf, 2020). Fruits have three placentas with normal seeds. Seeds are embedded in a gelatinous sheath.

Table 5. Characteristics depends to fruit gorgak melon cultivars studded in the current research						
No	Phenotypic character	Cultivars				
		Gorgakseya	Gorgaksafeed	Gorgaksabz	Kokgorgak	Gorgakablaq
1	Skin Characteristics	Reticulate	Reticulate	Reticulate	Reticulate	Reticulate
2	Days to mature fruit	86b	91a	89a	86b	85b
3	Fruit type	Reticulate Aromatc	Reticulatus Non-Aromatic	Inodorus Not-Aromatc	Reticulate Aromatc	Reticulate Aromatc
4	Fruit shape	Ovate	Globular	Ovate	Ovate	Ovate
5	Fruit skin color	RHS 202A+202D	RHS NN155D	RHS N134A+138C	RHS 17D+138A	RHS 202A+135A
6	Skin texture	Plain	Plain	Plain	Plain	Plain
7	Flash color	RHS140C	RHS157D	RHS140C	RHS 142C	RHS140C
8	Fruit width (cm)	16.1c	19.3a	18.5b	15.6d	19.5a
9	Fruit length (cm)	19bc	19.8b	23.9a	18.3cd	16.7d
10	Fruit skin thickness	Thin	Medium	Medium	Thin	Medium
11	Fruit sweetness (Brix)	19.9a ±82	17.6c ±64	18.2b ±58	18.7b ±46	17.6c ±32
12	Fruit mesocarp structure	Soft	Soft	Soft	Soft	Soft
13	Number of fruit per plant	4a	2c	3bc	3bc	3bc
14	Fruit smell	Medium	Medium	Weak	Medium	Weak
15	Fruit yield kg/m2	6.38a	5.76a	6.21a	3.75c	4.29b
Means followed by different letters in each row are significantly different at 5% probability level.						

Gorgak cultivars have small and round fruits. The fruit shape was flat and fruit weight was commonly between 1 to 3.5 kg can be observed. The impact of having or not having stamens, in the female flowers (known as locus a) on fruit shape must be mentioned: generally monoecious plants tend to have more elongated and larger fruits compared to isogenic andromonoecious plants. The shape of the fruit and ovary are interconnected and there have been descriptions of QTLs that're mainly recessive, for the length and width of both the fruit and ovary (Wehner et al. 2020; Pitrat, 2017). Based on seed morphological characters, we can say that the morphological characteristics of each Gorgaks were different from each other. There were no significant differences in the character of weight of 100 dry seeds, seed colors, seed area length and width of Gorgak melons (Table 6 and Figure 3).

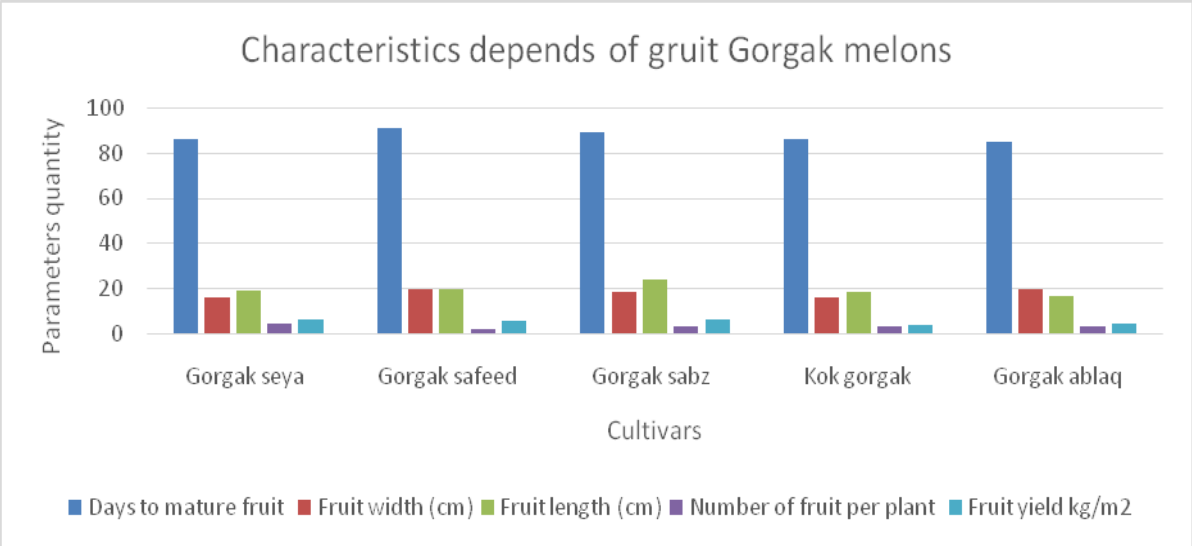

Figure 2. Characteristics like days to maturity, fruit width, fruit length, number of fruit per plant and fruit yield kg/m^2 of fruit Gorgak melons.

Table 6. Characteristics depend to seeds gorgak melon cultivars investigated in the current study.

No	Phenotypic character	Cultivars				
		Gorgak seya	Gorgak safeed	Gorgak sabz	Kok grogak	Gorgak ablaq
1	Seed shape	Ellipse	Ellipse	Ellipse	Ellipse	Ellipse
2	Seed color	RHS 163B	RHS 163C	RHS 163C	RHS 163 D	RHS 163C
3	Weight per 100 dry seeds	6.8a	6.9a	6.6a	7a	5.7b
4	Seed Area length in fruit	13c	14.8b	16a	12.8c	10.4d
5	Seed Area width in fruit	8.4b	10.7a	10a	7.6b	10.1a
Means followed by different letters in each row are significantly different at 5% probability level.						

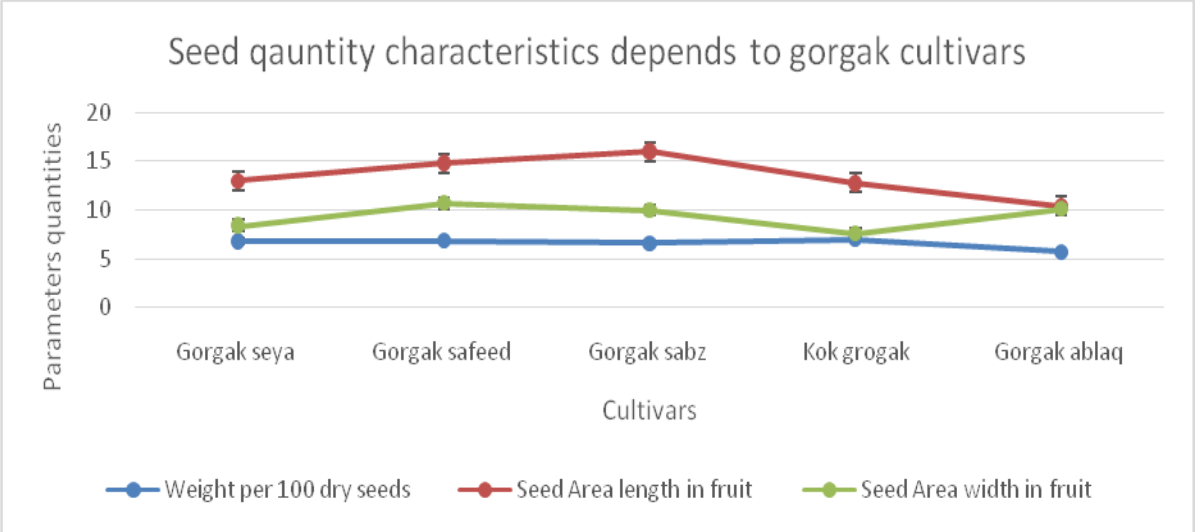

Figure 3. Seeds quantity characteristics depend to Gorgak melons like weight per 100 dry seeds, seed area length and seed area width in fruit

Based on analysis, we can say that the morphological characteristics of each Gorgaks were different from each other. In the characters of fruit length and weight, fruit vertical diameter, fruit sweetness, number of 100 dry seeds and its weight there were no significant difference in five types of Grogak melons.

The largest similarity index was held between the Gorgak melons, it is indicating that phenotypically, they are leaning similar to each other. Phenotypic traits are formed through the expression of genotypec traits and their interacts with the surrounding environment. Based on the result of this study, Gorgak seya, Gorgak ablaq and Gorgak sabz have fairly stable characters with high level of similarity. However, for mass production and development of Gorgak melons into a suitable cultivar, it must be done and selected more breeding planes. For this reason, we must do and conduct further study and research to the stability and volubility of the character to next generation of Gorgak melons.

CONCLUSION

It is concluded that Gorgaks showed different phenotypic characters from each other's on number of mean stems, number of lateral stems, stem length, bio-product, germination and days to 50 % maturity, leaf area, number of days to 50 % flowering, days to 50 % maturity, fruit type, color of fruit skin, fruit width and length, flesh color, fruit skin thickness, fruit test, number of fruits per plant and fruit yield, seed color, weight per 100 dry seeds, seed area length and width. Gorgak seya, Gorgak sabz and Gorgak ablaq demonstrated low morphologic variation, and high stability characters. Gorgak safeed showed the highest stability but for its development into a suitable cultivar for mass production, it must be done more breeding planes.

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