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| RESEARCH ARTICLE

The Adaptation Assessment of Different Sunflower Cultivars under Kabul Agro Climatic Conditions

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| ABSTRACT
Sunflower (*Helianthus annuus* L.) is one of the most important oilseeds crops due to its wide adaptability, mechanization potential, low labor requirements, and high oil and protein content. The present study was conducted to evaluate the performance of elite sunflower cultivars under Kabul agro-ecological conditions. The main objective of this research is to identify superior genotypes best adapted to Kabul agro-ecological conditions. Three improved cultivars of sunflowers, two from France (Robiacs and Imeriacs) and a local one were tested for two years, 2018-19, on the farm of Agriculture faculty at Kabul University. The experiment was arranged in a randomized complete block design (RCBD) with three replications. Data were collected on achene's yield and other parameters. Analysis revealed a highly significant difference among cultivars for all parameters under study except the number of days to complete emergence, number of plants m^{-2}, plant height and leaf area index. Among the cultivars examined, there were significant differences in achene yield. Local cultivar (4696.92kg ha^{-1}) followed by Robiacs (4346.62 kg ha^{-1}) yielded significantly higher than Imeriacs cultivar (3029). These cultivars have shown to be the best local and exotic genotypes in terms of achene's yield. With additional tastings, these potential lines could be released for specific environments in Afghanistan similar to the Kabul agro-ecology.

| KEYWORDS
Sunflower; Cultivars; Adaptation; Yield

| ARTICLE INFORMATION
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1. Introduction
Sunflower is an important oilseed crop because of its high protein and oil content (Canavar et al., 2010). The genetic-by-environment interaction reduces the correlation between phenotype and genotype, making it hard to detect the genotypic effects of a variety (Sincik & Goksoy, 2014). For complex traits like yield that are conditioned by many genes, environmental influence on performance is often high (Calamail *et al.*, 2018). For this reason, sunflowers need to conduct multi-environment performance tests on exotic sunflower varieties to determine their adaptability and stability. The presence of GXE interactions is often an indication of a lack of stability of genotypes across environments. However, the presence of GXE can be exploited in the selection of genotypes that are adapted to specific environments (Nouman, 2009).

In Afghanistan, limited research has been conducted on the adaptability of sunflower cultivars, and this has resulted in farmers growing varieties that are poorly suited to their environments, with eventual low yields. Each country needs cultivars that can produce higher yields, early maturity, and improved oil content under intense summer temperatures and drought conditions (Bakht et al., 2006). The development of well-adapted, high-yielding sunflower genotypes belongs to local agro-ecological conditions (Ahamad *et al.*, 2009).

At present, most edible oil is imported to Afghanistan, while the country's ecology has been suitable for the production of oily crops such as cotton, soybean, sunflower...etc. Currently, the need for edible oil consumption in the country is 504011 tons while domestic production is 5673 tons of oil, of which 5610 tons come from the private sector, and 63 tons are produced by the government (Afghanistan Statistical Center). Cultivation of oilseed, including sunflower, is not happing at a large scale, and only about 493 hectares of the area was sown with oily crops in 2016, with an average production of 2.650 tons (Sharifi, 2020). Sunflower is grown on an area of 457 hectares in Afghanistan, with a production of 723 tons in 2017 (FAO, 2017). The average achene yield of sunflower in Afghanistan is very low (1808 kg/ ha^{-1}) compared to other sunflower-growing countries, with a yield of 3876 kg/ ha^{-1} (Canavar *et al*., 2010). Low sunflower production in Afghanistan is due to the absence of a systematic market, no availability of seeds, adaptation to local environmental conditions, and the development of local cultivars/hybrids .The cultivation of exotic cultivars, which are not well suited to agro-climatic conditions, is one of the reasons for the low production of sunflower seeds (Sarwar *et al*., 2013).

Sunflower production is greatly affected by the choice of hybrid or variety (Mazhar *et al.,*2005). It is important to consider many factors when selecting a cultivar, including seed yield potential, oil content, oil composition, maturity, stalk strength, and disease resistance. Oil of seed sunflower unsaturated acid for human consumption. (Fabian et al., 2014). Sunflower seed is used as food, and its dried stalk is used as fuel. It is already being used as an ornamental plant, and its stalk was used as fuel in ancient ceremonies (Fabian et al., 2014). Additionally, for medical uses, for instance, pulmonary afflictions have been reported. Besides, parts of these plants are used in making dyes for the textile industry, body painting, and other decoration. Its oil is used in salad dressings, for cooking and in the manufacturing of margarine and shortening (Kunduraci et al., 2004 & John et al.,2006).

Almost all seeds of sunflower cultivars are imported, and due to different agro-ecological circumstances of their development, evaluation, and production, so the full potential of yield is not achieved in our climatic conditions. Furthermore, there is always potential danger and threat of new insect pests and diseases (Sarwar et al., 2013). One of the reasons for the low production of sunflower seed is the cultivation of exotic hybrids, which are not well adapted to agro climate conditions (Ahamad et al., 2009). Every country needs cultivars that can produce higher yield, early maturity and improved oil content under intense summer temperature drought conditions (Bakht et al., 2006). The development of well-adapted, high yielding sunflower genotypes belongs to local agro-ecological conditions (Ahamad *et al*., 2009). Temperature is a major environmental factor that determines the rate of plant growth and development. (Qadri et al.,2007).

Thus, the main objective of this research is to evaluate the performance of elite sunflower cultivars, identify superior genotypes best adapted to Kabul agro-ecological conditions, and identify varieties that have high yield capacity.

1.1 Materials and Methods

The research was conducted in the farm of Agriculture faculty at Kabul University during the 2018-2019 crop years. Three improved cultivars of sunflowers, two from France and a local one, were tested. A randomized complete block design (RCBD) with three replications was used to set up the experiment. The soil of the research farm is silty loam with a PH of 8.01 and CEC (Cation Exchange Capacity) of 0.17.

A field was first irrigated, then plowed when ready for tillage. Plots, irrigation channels, and bunds were constructed manually. Healthy and matured seeds with good germination (96%) were used. The germination of all sunflower cultivars was tested before planting, and the seed rate used was 6kg ha^{-1}. During cultivation, fertilizer was applied at a rate of 200 kg ha^{-1} DAP, and urea was used three times—during cultivation, vegetative, and flowering stages—at a rate of 160 kg ha^{-1}. Furrow irrigation was applied, and the irrigation was done once a week regularly and continued until physiological maturity (seeds of head). Weeds control was done by hand, as well as some primitive tools. (Mainly once every two weeks). The observation regarding Days to emergence, Numbers of plant m^{-2}, Days to flower completion, Days to maturity, Plant height (cm), Number of leaves $plant^{-1,}$ Leaf area index, and post-harvest observations include head diameter (cm), numbers of achene $head^{-1,}$ thousand achene weight/test weight (g), achene yield (kg ha^{-1}). Days to emergence were recorded from the date of sowing until more than 90% of the seeds got emerged in each plot. Number of plants was calculated from the whole plot and then converted into plant m^{-2}. Plant height was measured randomly from 4 plants of each row from ground level to the top edge of the collar disc, and then their average was calculated. A number of functional leaves, $plant^{-1,}$ was counted and recorded. In each cultivar, days to flower completion were recorded by visual observation. The number of days to maturity was recorded when the outer bracts of the flower heads turned brown, the back of the heads turned lemon yellow, and the seeds were easily detachable. The head diameter of 4 plants of each row was measured from one edge to the other, and the average was calculated. Similarly, total grains $disc^{-1}$ was counted, and averages were computed. The average weight of 1000 grains from each plot was counted. The heads were harvested by a knife. Flower heads were sun-dried and then threshed manually to separate the seeds. The threshed produce was winnowed, and seed yield from each plot was recorded after drying and then converted to kg ha^{-1}. Four plants were randomly selected from the central of two rows in each treatment for measurement. For the duration of the growing period, all other agronomic procedures were normal and uniform for all treatments. SAS and Star statistical software were used to analyze the data recorded on various parameters during the study.

2. Results and Discussion

2.1 Days to Emergence

The number of days to emergence was not significantly affected by various sunflower cultivars during both years (Fig.1). Maximum days to emergence were recorded in cultivar Imeriacs 16, followed by cultivar Robiacs with 12 days to emergence. Minimum numbers of 11 days to emergence were recorded in the case of Local. Ali *et al.* (2013) reported differences between seed germination were due to seed viability, size, and environmental factors. Bakht *et al*. (2006) recorded variation in seed germination due to seed viability, environmental factors, and genetics.

2.2 Number of Plants m^{-2}

The number of plants m^{-2} was not significantly affected by various sunflower cultivars during both years (Fig.2). The maximum plant population was observed in Robiacs (4.4 m^{-2}) and followed by Imeriacs (4.3 m^{-2}). The minimum plant population was recorded in the case of Local (4.2 m^{-2}). Sarwar *et al*. (2013) reported that germination percentage played a significant role in differences among hybrids in plant population per unit area. Durby *et al.* (2011) indicated that a wet and cool spring may have resulted in poor seed germination and stand establishment. Compacted soil may have also reduced seedling emergence. These findings are by Ali *et al*. (2013); it should be noted that some scientists have reported significant differences between sunflower hybrids Bakht *et al*. (2006), Sarwar *et al*. (2013) and Darby *et al.* (2011) contrary to the present results.

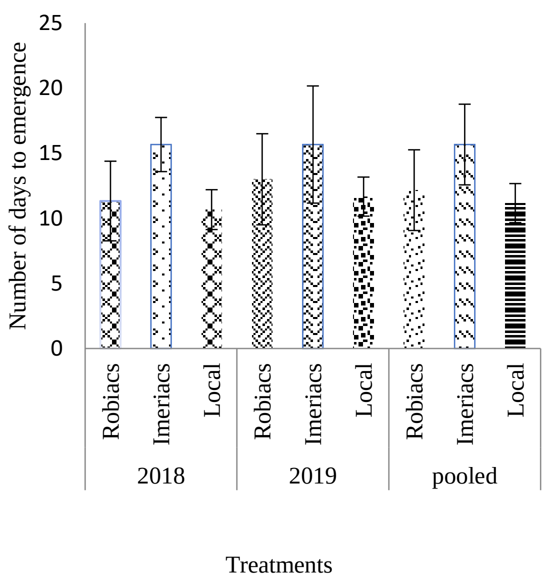

Fig 1. Effect of treatmnts on sunflower emergence during at 2018-2019.

2.3 Days to

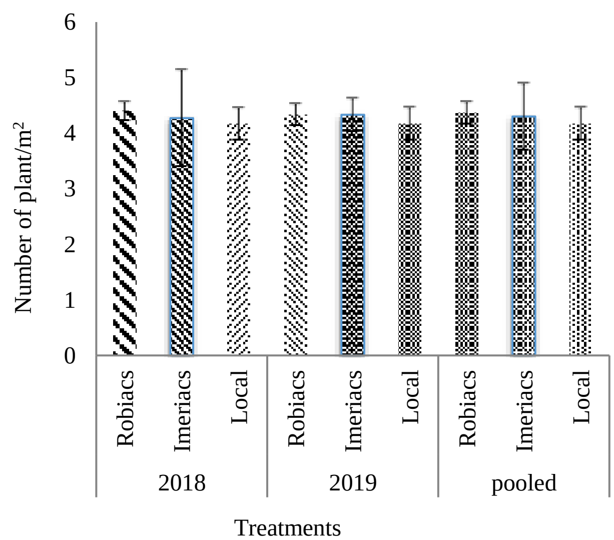

Fig 2. Effect of treatments on number of plant during at 2018-2019.

Days to Flower Completion

The number of days to flowering was significantly affected by various sunflower cultivars. According to the combination of two years, the maximum number of days to flower completion was recorded in cultivar Imeriacs 79, followed by cultivar Robiacs with 73 days to flower completion. The minimum number of days 61 to flower completion was observed in the Local cultivar (Fig 3). Differences among cultivars for flower completion are due to genetic makeup, and dwarf plants' need a minimum of days to flower completion. These results are partially in line with Ali *et al*. (2013) and contrary to Bakht *et al*. (2006).

2.4 Days to Maturity

The number of days to maturity was statistically different during the growing seasons of two years. Imeriacs took the maximum number of 139 days to maturity, which was followed by cultivar Robiacs with 128 days to maturity. The minimum number of days 123 to maturity was observed in the Local cultivar. Short plants have a shorter growing season than tall plants.

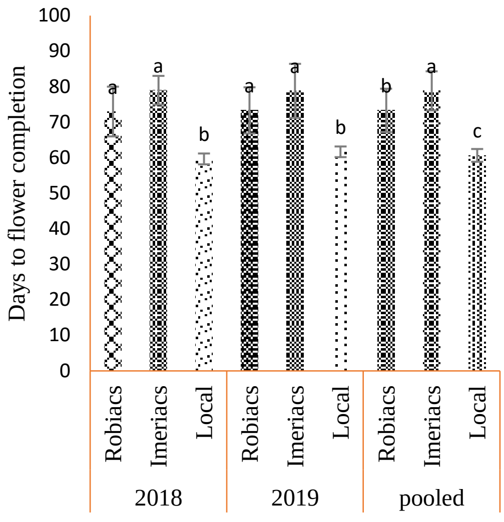

Fig 3.Days to flower complation of different sunflower cultivars. Different letters mean significant diferences at LSD(p< 0.05).

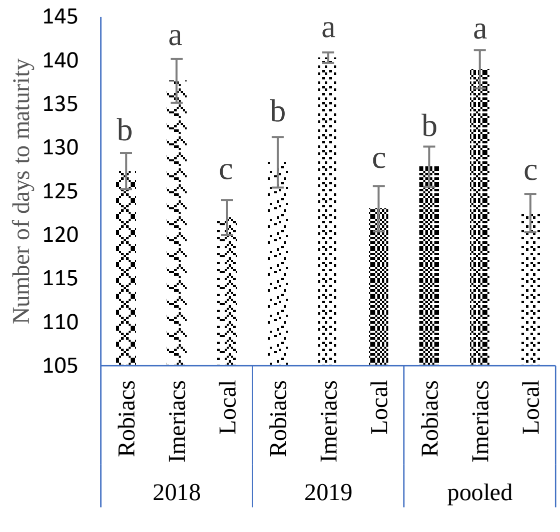

Fig 4. Deferences among days to maturity of different sunflower cultivars. Differents letters mean significant diferences at LSD (p< 0.05)

2.5 Plant Height

Based on the combination of two years, there were no significant differences among various sunflower cultivars in the case of plant height (Fig.5). Among the treatments, Imeriacs had a maximum plant height of 169 cm, followed by the cultivar Robiacs with 164 cm. A minimum plant height of 159cm was recorded in the case of Local. Qadri *et al*. (2007) reported Temperature is a major environmental factor that determines the rate of plant growth and development. Canavar *et al.* (2010) found in the growing season, plant height varied due to climate changes such as temperature and sun radiation. Sarwar *et al*. (2013) reported Plant heights differ among hybrids due to environmental variations and genetic characteristics.

2.6 Number of Leaves Plant^{-1}

The results of the analysis of the data indicated significant differences among varieties of sunflower cultivars due to leaf plant^{-1}. The highest leaf number per plant, 20, was recorded for Imeriacs, followed by the Local 18 leaf number per plant. The lowest leaf number plant^{-1} 17 was obtained from Robicas (Fig.6). Canavar *et al.* (2010) reported leaves function apparatus. Therefore, an increase in the number of leaves per plant indicates an improvement in the source of photosynthesis that can be translocated to the sink. These results are agreed with Let (2014) and contrary to Calamai *et al.* (2018) and Bakht *et al.* (2006).

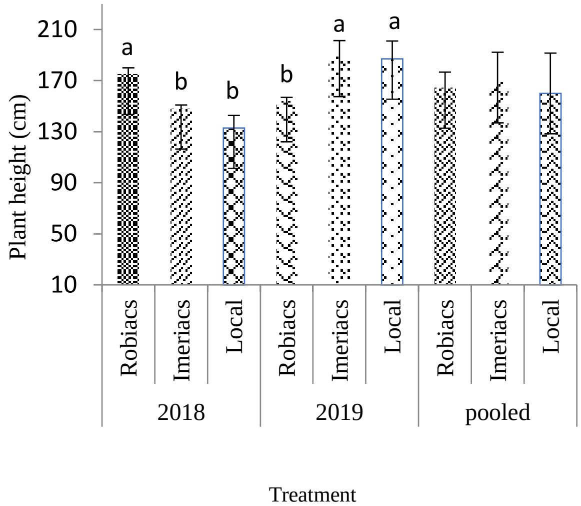

Fig 5.Effect of treatments on plant height of deferent sunflower cultivars in during at maturity.
Different letters mean significant diferences at LSD (p< 0.05)

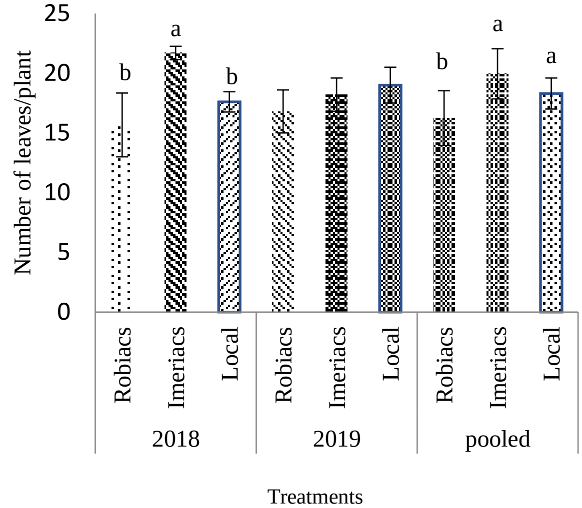

Fig 6. Effect of treatments on leaves number of deferent sunflower cultivars.
Different letters mean significant diferences at LSD (p< 0.05).

2.7 Leaf Area

Analysis regarding the leaf area revealed no significant differences in all the crop growth stages in terms of LAI among the sunflower cultivars under Kabul agro-ecological conditions. The biggest leaf area index (122.14) was obtained from the Local cultivar, followed by the Robicas (111.76) leaf area index. The lowest (100.7) leaf area index was obtained from Imeriacs (Fig.7). IAI has a direct effect on sunflower yields. Sarwar *et al*. (2013) observed different leaf area indexes for different hybrids due to differences in the genetic makeup. During the early growth phase of sunflowers, the leaf area index was low, increasing gradually over time and reaching its maximum value during flowering. This result is partially in line with those of Let (2014), Goksoy *et al.* (2002) and Sarkar and Mallick (2009). Contrary to Sarwar *et al*. (2013).

2.8 Head Diameter

An evaluation of the comparative performance of sunflower cultivars under Kabul agro-ecological conditions revealed significant differences in head diameter between cultivars. (Fig.8). The largest head diameter was obtained from the Local cultivar (30.02cm), followed by cultivar Robiacs with (29.83cm) head diameter. The smallest head diameter was recorded in Imeriacs (21.32cm). Adnan *et al*. (2009) Reported A crop that matured at cold temperatures and remained in the field for a long period had larger head diameter values. Therefore, crops that matured at low temperatures had smaller head diameters. Killi and Altunbay (2005) reported that Planting dates significantly affected head diameter.

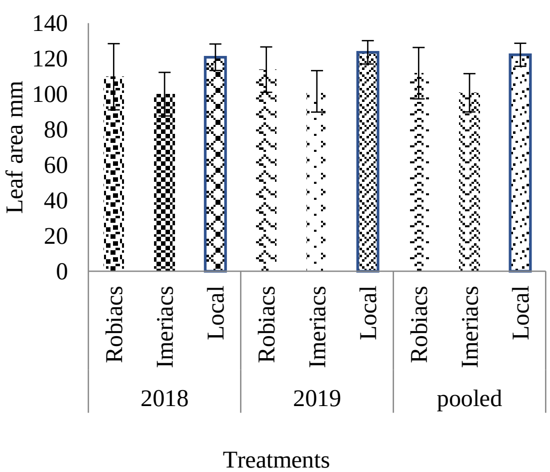

Fig 7. Leaf area of different cultivars of

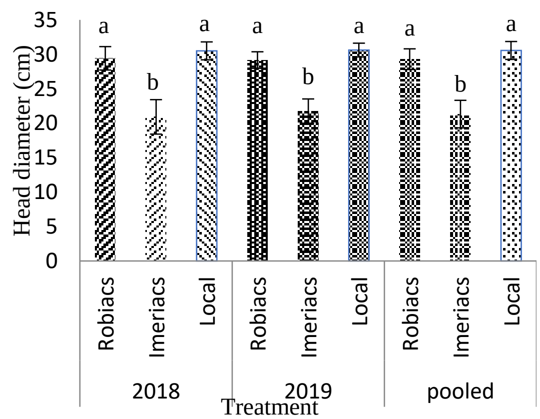

Fig 8. Differernces among sunflower cultivars in head diameter. Different letters mean significant diferences at LSD (p<0.05).

2.9 Numbers of Achene per Head

Statistical analysis of the data for the various sunflower cultivars showed there were significant differences in achene per head among the cultivars during both years. Data on the number of achenes per head are presented in (Fig. 9).

The highest number of achenes per head (1173.5) was recorded in Robiacs, which did not significantly differ from the Local cultivar (1090.97) achene per head, respectively. However, the lowest number of achenes per head (764.9) was recorded in Imeriacs. Qadri *et al*. (2007) found when the temperature declined or increased toward the maturity of the crop, the number of achenes per head decreased. The number of achenes per head decreased significantly as planting was delayed, according to Killi and Altunbay (2005). The results were obtained from Sarwar *et al*. (2013) and Bakht *et al*. (2006).

2.10 1000-Achene Weight

Achene weight represents the development and plumpness of achenes and is an index of yield. The data on 1000-achenes weight are presented in Figure 10. The analysis of the data revealed there were significant differences among treatments in the case of 1000 achene weight during both years. The highest 1000-achene weight (103.5gr) was recorded in Local, followed by Imeriacs (97.6gr). However, the lowest 1000-achene weight (85.09gr) was recorded for Robiacs.

Killi and Altanbay (2005) observed that the planting dates significantly affected the weight of 1000 seeds. All yield attributes would be reduced if sunflowers are planted late during autumn. This change in TSW was caused by genotype-specific factors. Furthermore, environmental conditions had positive or negative effects on genotypes. These results are supported by Sarwar *et al*. (2013), Bakht *et al*. (2006), Qadir *et al.* (2007), and Ali *et al*. (2013).

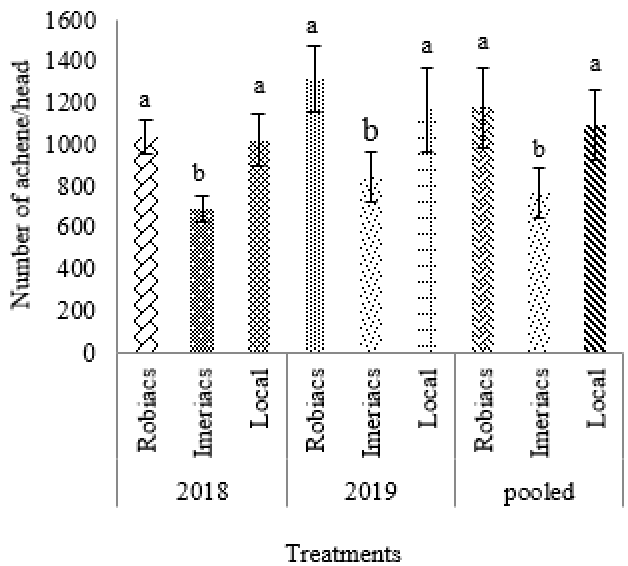

Fig 9. Effect of treatments on achene head of different sunflower cultivars.
Different letters mean significant diferences at LSD ($p < 0.05$).

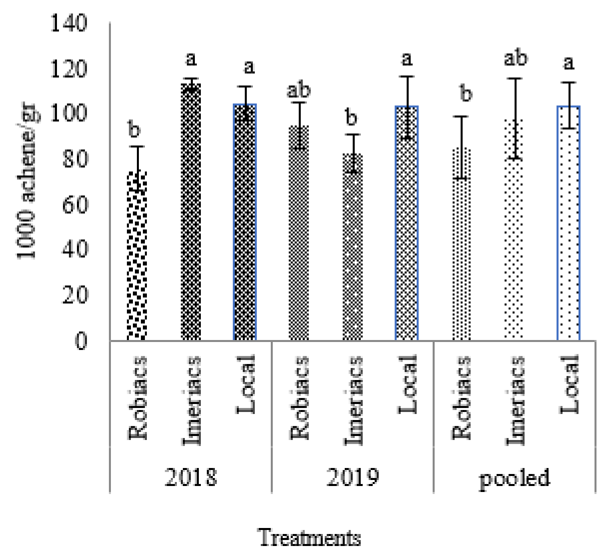

Fig.10. Effect of treatments on 1000-achene weight of different sunflower cultivars.
Different letters mean significant diferences at LSD ($p < 0.05$).

2.11 Achene Yield (kg ha^{-1})

Achene yield is the net result of the interaction of various factors and is a valid criterion for comparing the efficiency of different treatments. The ultimate objective of all agronomic studies is to optimize the yield of any crop. Statistical analysis of the data of both years revealed Local cultivar had the highest achene yield ha^{-1} (4696.92 kg ha^{-1}), closely followed by the Robiacs cultivar (4346.62 kg ha^{-1}) achene yield ha^{-1}, respectively. However, the lowest achene yield ha^{-1} (3029.02 kg ha^{-1}) was recorded in Imeriacs.

Ali *et al*. (2007) reported that there was a significant effect of different plant populations, the diameter of the head, the number of achenes per head, and 1000-achene weight on achene yield. Sincik and Goksoy. (2014) indicated that plant height, head diameter, and 1000-seed weight all positively correlated with seed yield. Calamai *et al.* (2018) demonstrated that Limited root-soil exploration can lead to nutrient deficiencies and a decrease in sunflower yields. Qadri *et al.* (2007) found yield and yield attributes may have been affected by environmental factors, especially temperature, during the period of seed development and maturation. Achene yield is determined by the combination of all the yield components under a particular set of environmental conditions. Planting date delay gradually reduced achene yield. Environmental variables may be responsible for the variation in achene yields. The same results are reported by Sarwar *et al.* (2013), Bakht *et al.* (2006) and other researchers as well.

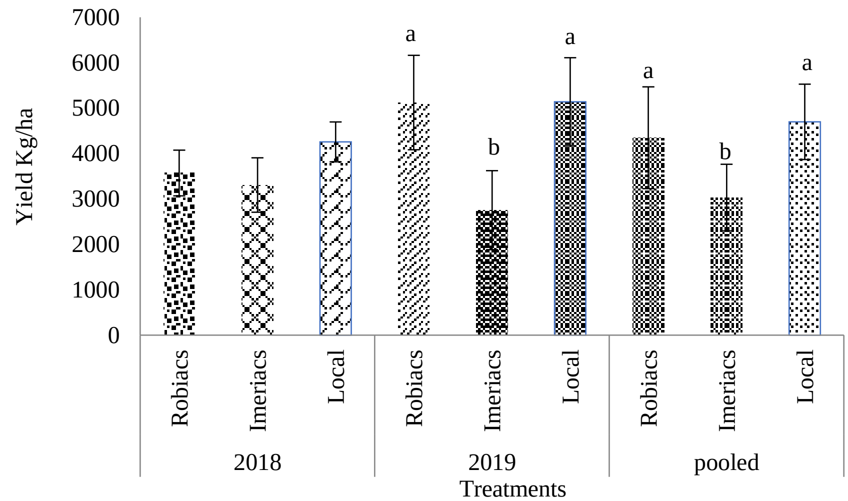

Fig 11. Difference among sunflower cultivars in achene yeild. Different letters mean significant differences at LSD (p<0.05).

Tab. 2. Growth and yield parameters of various sunflower cultivars under Kabul agroecological conditions.

Tereatments	Days to emergence (No)	Number of plant m^2	Leaves /plant (No)	Plant height cm	Leaf area (mm^2)	Days to flower completion (No)	Days to maturity (No)	HD (cm)	A.H Number	TSW (gr)	Sy (kg/ha)
Robiacs	12	4.3	17	164	112	73b	128b	30a	1173a	85b	4347a
Imeracs	16	4.3	20	169	100	79a	139a	21b	765b	98ab	3029b
Local	11	4.1	18	160	122	61	123c	30a	1091a	104a	4697a
Mean	13	4.2	18	164	112	71	130	27	1010	95	4024
± STD	2.36	0.1	17	4.3	11	9.3	8.4	4.9	216	9.4	880
CV	24.5	7.3	8	4.2	12.5	5.5	0.9	5.5	14.2	10.3	20
LSD P< 0.05	NS	NS	1.8 **	NS	NS	5.2 **	1.7 **	2 **	191 **	13.1 **	1090 *

*, **, represents the significant level of P<0.05 and P< 0.01 respectively

3. Conclusion and Recommendations

The following results were collected from the experiment: phonological results of the study showed cultivars differed significantly in all studied parameters except the number of days taken to emergence, the number of plants m^{-2}, leaf area index, and plant height. Local cultivars completed their flowering and reached maturity in a minimum number of days. The best characteristic of local cultivars is dwarf in plant height and varies resistance to the wind in the late season. Maximum head diameter, the highest number of achene's head^{-1} and 1000- achene's weight observed in Local and Robiacs cultivar. The achene's yield was affected significantly by head diameter, number of achenes per head, and 1000-achene weight.

Additionally, there were significant differences between the cultivars under study in terms of achene yield. Cultivar Local produced the highest yield of achenes (4696.92kg ha^{-1}) followed by hybrid Robiacs (4346.62 kg ha^{-1}), while the Imeriacs cultivar showed minimum achene’s yield (3029kg ha^{-1}). Achene yield was significant at 64.4% in local variety compared with Imeriacs. From the above mentioned, we concluded that the Local and Robiacs cultivar has a high yield and were best adapted to the Kabul agro climate conditions. Local cultivars had a good adaptation in Kabul agro climate conditions and the best potential for achene's yield as compared to other cultivars. Hence, this cultivar is recommendable in Kabul and the same agro-climate zones as well. Robiacs are late maturity with the highest amount of yield variety, and it is recommendable for those zones that have a warmer climate, like Baghlan, Kunduz, and Takhar.

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