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RESEARCH ARTICLE

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Effect of Sowing Dates and Planting Densities on Yield and its Components of Three Varieties of Sesame (*Sesamum indicum* L.) in the Samangan Environment

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ABSTRACT

Background: Sowing date and planting density are the main factors playing a prominent role in determining the yield of crops. Sowing date has the most significant impact on the phonological and growth characteristics of plants compared to other crop traits. On the other hand, in low planting densities, environmental facilities, including light, space, water and soil, are not optimally used, ultimately reducing yield. Sesame yield is highly variable depending upon the growing environment, cultural practices and cultivars.

Methods: The study was planned to determine the effect of different sowing date (April 10th, May 10th and June 10th) and planting densities (20, 30 and 40 plants/m2) on three sesame varieties (Balkh, Baghlan and Samangan), during the 2022 and 2023 cropping seasons at the experimental field of Samangan University, Afghanistan. The experiments were conducted as split-plot factorial in randomized complete blocks design with three replications.

Result: The results revealed significant effects of sowing date and plant density on all studied traits across both years. The highest seed yield (1.6 t/ha) was achieved with Balkh variety, sown on April 10th and a plant density of 40 plants/m^2. Conversely, Baghlan variety, sown on June 10th, at 20 plants/m^2, yielded the lowest (0.9 t/ha) in 2022. The study underscores the importance of sowing date and plant density in optimizing sesame yield. Early sowing (April 10th) and higher plant density (40 plants/m^2) were associated with superior seed productivity, highlighting their significance for sesame cultivation in the region.

Key words: Plant density, Seed yield, Sesame, Sowing date, Variety.

INTRODUCTION

Sesame plant (*Sesamum indicum* L.) is one of the most important and oldest oil seeds known and used by mankind Bedigian, (2004). In order to improve the quantitative and qualitative performance of agricultural plants, it is inevitable to apply correct agronomic methods along with genetic modification to use the maximum productive capacity of plants, varieties selection, planting date and plant density are among these managements (Ebrahimian *et al*., 2019). Farmers of Samangan region usually cultivate sesame from the first of April to the end of July failure to choose the appropriate planting date causes the flowering of sesame to coincide with high temperature and as a result, the number of capsules per plant decreases due to the lack of fertility of the flowers. Finding the best sowing date according to the climatic conditions of the region is one of the essentials of agricultural management, because it causes the germination, growth and establishment of the seedlings in accordance with favorable climatic conditions and the vegetative and reproductive stages of the plant in terms of temperature, light and humidity in favorable conditions. In this case, the plant grows ideally and can produce acceptable quantitative and qualitative performance. Planting date has a very important effect on the yield and yield components of oilseeds and whatever we get distance from the optimal planting date, the seed and oil yield will decrease (Ahmed *et al*., 2009). In research of Monpara and Vaghasia, (2016), they showed that the planting date of May 20 was superior to the planting date of June 5 in terms of yield and yield components of sesame. The results of the investigation by Khaskheli, (2009) in Pakistan showed that the effect of variety and planting date on the yield and yield components of sesame was significant at the 1% level.

Planting density is one of the most important agronomic topics of farm management, which unfortunately has received less attention in the case of sesame. On the other hand, reducing the spacing of the planting rows can increase the spacing of the plants on the planted row and as a result, the distribution of the plants per unit area will be more uniform Bhardwaj *et al*. (2014). This can cause effective use of resources and increase the efficiency of light absorption during the growth period of plants and due

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to the production of more photosynthetic substances, the necessary infrastructure for the formation of more yield components and ultimately higher grain yield will be provided Aslam *et al*. (2015). Also, Ali *et al*. (2020) cleared that significant differences were observed in row spacing, varieties and the interaction between row spacing and varieties for all studied parameters except the 1000-seed weight. In a study of Roy *et al*. (2009) reported that the highest seed yield and yield components were obtained with a density of 33 plants per square meter.

In this study, the effects of sowing date and planting density on different varieties of sesame were evaluated in order to determine the best variety among the cultivated varieties according to the climatic conditions of the region and planting density per unit area.

MATERIALS AND METHODS

This experiment was carried out in 2021-2022 and 2022-2023 at the experimental field of Samangan University, Afghanistan. The geographical position of area lies between 36° 30′N and 68° 01′E with the elevation of 985 m above sea level. According to meteorological agency record the area receives mean annual rainfall and temperature of 835.6 and 766.4 mm and 26.7°C and 28.4°C in 2022 and 2023 crop year, respectively. This experiment was conducted as a split-plot factorial in randomized complete block design with 3 replications. The treatments were three sowing dates (April 10th, May 10th and June 10th) assigned to the main plots, thrree planting densities (20, 30 and 40 plants/m^2) and three varieties including Balkh, Baghlan and Samangan as subplots. To determine the soil characteristics, soil samples were taken from 0-30 cm depth before planting varieties of sesame. Soil properties of the research field at the experimental site are shown in (Table 1). The size of each sub-plot was 8 m^2 (4×2m), including 4 rows. The distance between plots and blocks were 1 and 1.5 m respectively. In order to achieve the desired plant densities, seeds were sown at a high density, after sprouting and at the 4-6 leaf stage, the lines were thinning. Weeding was done manually three times. Irrigation of the experimental units was done every 7 days based on the need. Harvesting was done manually in both years when all capsules of the plant were ripe and turned brown. To determine the grain yield, the middle two rows of each sub-plot were harvested by removing a total of one meter from the beginning and end of each row with an area of 2 m^2. In order to measure study traits such as plant height, number of branches/plants, number of capsule/plants, number of seeds/capsules, ten plants were randomly selected from each sub-plot and these traits were measured. The analysis of variance was performed using SAS software and was used to compare the averages of the main effect and interaction effects using the least significant differences (LSD) test at the 5% level.

RESULTS AND DISCUSSION

Plant height (cm)

Plant height was only significantly affected by interaction of sowing date and plant density. Means comparisons of the interaction of sowing date and plant density showed that the highest plant height was obtained with sowing date of May 10 and plant density of 40 plant/m^2, but the lowest plant height was observed with sowing date of June 10 and plant density of 20 plant/m^2 in both seasons (Fig 1). It seems that increasing plant density at early sowing date increased plant height of sesame in both seasons. The same results reported by Aghili *et al*. (2015). These results are in accordance with the finding of Caliskan *et al*. (2004) who reported that generally denser plant cultivations produce longer stems, due to the effects of the composition of the light that penetrates the plant canopy, while the larger spacing causes the development of vegetative lateral shoots. El naim *et al*. (2010) also reported that increasing plant population increased plant height in sesame. Many studies indicated that increasing plant density led to the larger competition between plants for available nutrients and other growth resources Ngala *et al*. (2013). In term of varieties the highest plant height recorded with Samangan variety and the lowest plant height recorded with Balkh variety both seasons. The same results were found by Farokhian *et al*. (2021) who reported that a significant difference was observed among varieties of sesame plant.

Number of branches/plants

The number of branches/plants was significantly influenced by sample effect of sowing dates, planting densities, varieties and their interactions (Table 2). It had been observed that the most branches/plants obtained with sowing date of April 10, plant density of 20 plant/m^2 and Balkh variety, while the lowest branches/plant obtained with sowing date of June 10, planting density of 40 plant/m^2 and Samangan variety in 2022 and 2023 seasons (Fig 2). Delaying planting date from April 10 to June 10 decreased number of branches/plants while there is no significant different between sowing date of May 10 and June 10 in both seasons. This result agreement with Ahmed *et al*. (2009). It seems that Increasing plant population lead to decrease number of branches/plants. Sesame at the wider space within row receipting maximum sunlight for the process of photosynthesis, increased photosynthesis leads to increasing the plant growth, biomass and the number of branches per plant Idoko *et al*. (2018).

Table 1: Soil properties of the research field.

Clay	Silt	Sand	N	P	K	Fe	Mn	Cu	pH	Ec	Organic material
	%		%			(mg/kg)					%
44	25	31	0.15	6.8	340	1.19	2.3	0.9	7.6	0.68	0.9

Number of capsules/plants

Effect of sowing date, plant density and their interaction on number of capsules/plants in 2022 and 2023 are presented in (Table 2). The highest number of capsules/plants was recorded in sowing date of April 10 and planting density of 20 plant/m^2, while the lowest number of capsule/plant was recorded in sowing date of June 10 and planting density of 40 plant/m^2 in both seasons (Fig 3). Delay planting date

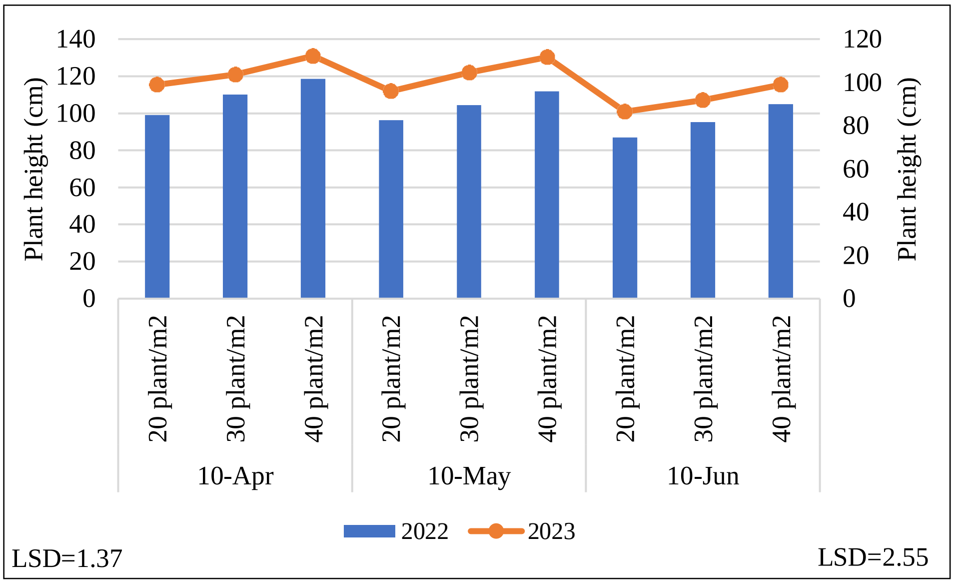

Fig 1: The effect of interaction between sowing date and plant density on plant in 2022 and 2023 seasons

Table 2: Effect of sowing date, plant density, variety and their interaction on agronomic traits of sesame in 2022 and 2023.

Source	DF	Plant height	No. of branches /plant	No. of capsules /plant	No. of seeds /capsule	1000 seeds weight	Seed yield	Biological yield	Harvest index
					2021 - 2022 season				
Replication	2	602.08	0.75	13.37	42.81	0.01	0.01	0.02	4.51
SD	2	1256.03^{ns}	16.69**	1131.36**	540.58**	0.55*	0.25**	0.30**	73.16**
Error 1	4	453.250	0.194	18.898	7.898	0.060	0.007	0.007	2.00
PD	2	2121.19**	12.03**	688.53**	561.33**	2.53**	1.09**	1.15**	316.82**
V	2	208.36**	6.77**	4.19^{ns}	0.33^{ns}	0.06**	0.01^{ns}	0.09^{ns}	2.77^{ns}
SD×PD	4	12.90**	1.19**	11.44**	21.92**	0.02**	0.04**	0.12**	14.38**
SD×V	4	4.69^{ns}	0.19^{ns}	1.11^{ns}	0.42^{ns}	0.03**	0.01^{ns}	0.14^{ns}	2.99^{ns}
PD×V	4	4.24^{ns}	0.40^{ns}	1.53^{ns}	2.92^{ns}	0.01^{ns}	0.01^{ns}	0.15^{ns}	1.62^{ns}
SD×PD×V	8	0.94^{ns}	0.82**	1.88^{ns}	1.38^{ns}	0.01**	0.01*	0.11*	3.27*
Error 2	48	2.069	0.171	2.326	1.370	0.004	0.005	0.05	1.293
CV (%)	13.95	10.39	3.24	2.38	2.40	5.42	1.60	3.87	
					2022 - 2023 season				
Replication	2	457.82	0.28	17.94	34.48	0.01	0.03	0.04	0.33
SD	2	1323.21*	7.99**	1092.54**	487.79**	0.57*	0.21**	0.12*	65.57**
Error 1	4	111.716	0.280	21.530	11.018	0.034	0.002	0.012	2.394
PD	2	1289.35**	11.08**	635.46**	508.78**	1.97**	0.49**	0.81**	95.52**
V	2	70.11**	5.12**	2.13^{ns}	0.04^{ns}	0.04**	0.01^{ns}	0.01^{ns}	2.22^{ns}
SD×PD	4	11.29**	0.17^{ns}	8.14**	14.70**	0.05**	0.02**	0.06**	4.55^{ns}
SD×V	4	0.37^{ns}	0.17^{ns}	1.31^{ns}	0.44^{ns}	0.03**	0.01^{ns}	0.02^{ns}	1.10^{ns}
PD×V	4	2.42^{ns}	0.72**	0.51^{ns}	2.51^{ns}	0.01*	0.01^{ns}	0.01^{ns}	2.80^{ns}
SD×PD×V	8	3.89^{ns}	0.63**	0.88^{ns}	0.78^{ns}	0.01*	0.01^{ns}	0.03^{ns}	3.73^{ns}
Error 2	48	7.152	0.08	1.805	1.207	0.007	0.006	0.009	1.91
CV (%)	2.66	5.71	2.49	2.43	3.36	5.32	2.13	4.35	

SD: Sowing date, PD: Planting density, V: Variety, ns, * and **: No significant, significant at 5% and 1% probability level, respectively.

led to decreases number of capsules/plants; earlier planting date gained prolonged growth period with ideal growth condition produced higher number of capsules/ plants as compared to late planting. Similar trends were obtained by Alamsarkar *et al*. (2007) who reported that delay in planting decreased the number of capsules/plants. Also, this result was in line with Caliskan *et al*. (2004). In term of variety there was no significant different effect between varieties, while Tahir *et al*. (2012) revealed that the number of capsules/plants was influenced by varieties.

Number of seeds/capsules

The number of seeds/capsules was significantly influenced by sowing date, planting density and only their interaction sowing date × planting density in both years (Table 2). The maximum number of seeds/capsules was recorded in sowing date of April 10 and planting density of 20 plant/m^2, while the minimum number of seeds/capsules was recorded in sowing date of June 10 and planting density of 40 plant/m^2 in 2022 and 2023 seasons (Fig 4). These results were accordance to finding of Monpara and Vaghasia, (2016), who indicated that significant differences among sowing date for number of seeds/capsules, it was significantly higher at early sowing date than lately sowing date. Similar results found by Caliskan *et al*. (2004) who revealed that the maximum number of seeds/capsules were obtained with lowest plant population, plant grown at low populations received a higher red-light ratio compared

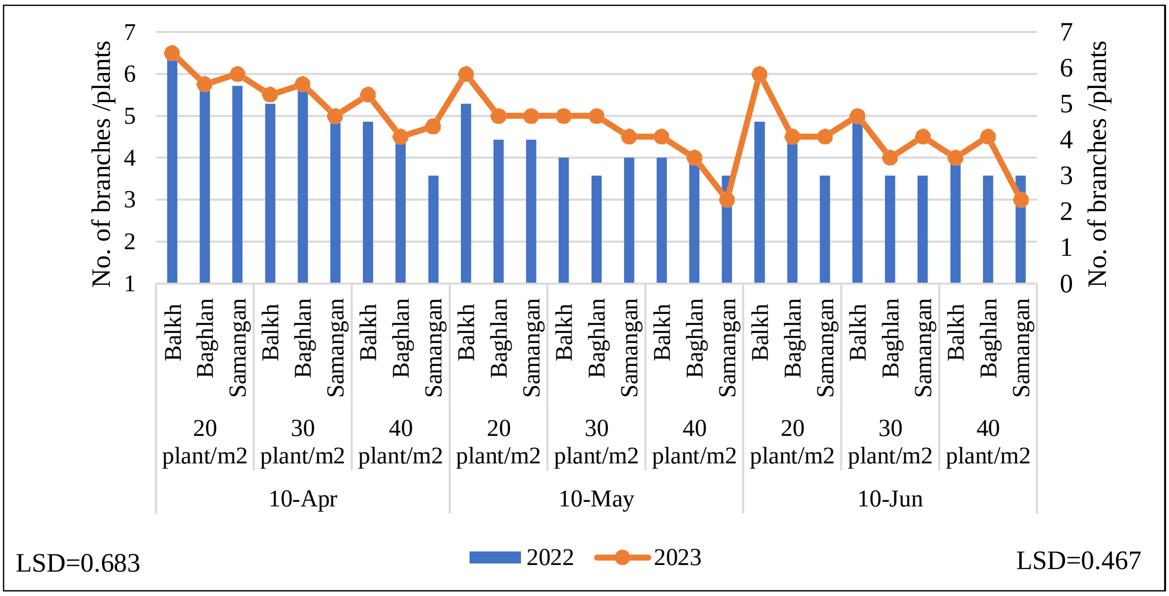

Fig 2: The effect of interaction between sowing date, plant density and variety on number of branches/plants in 2022 and 2023 seasons.

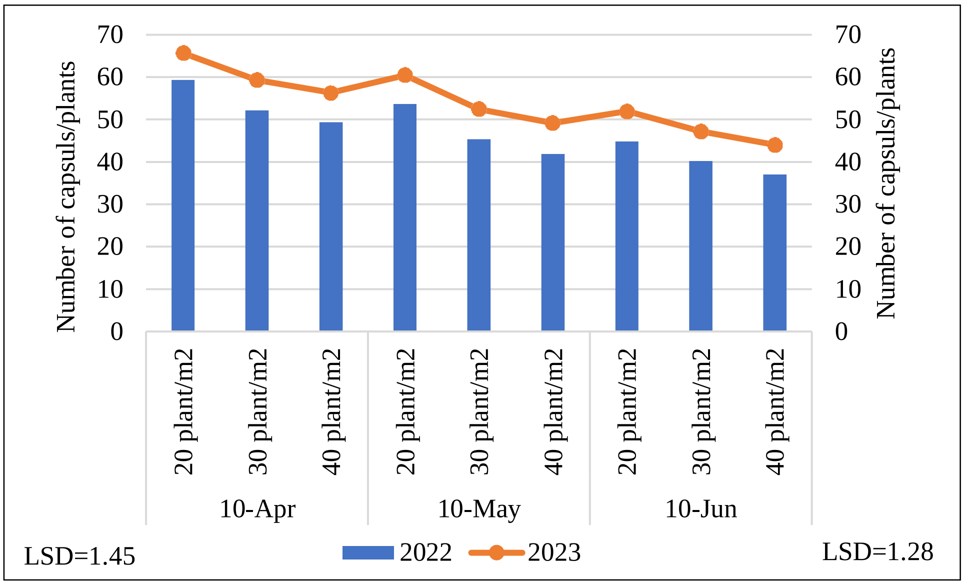

Fig 3: The effect of interaction between sowing date and plant density on number of capsules/plants in 2022 and 2023 seasons.

with denser populations which caused a greater portion of total vegetative dry matter to be partitioned in to branches. On the contrary, number of seeds/capsules was not affected by change in plant density Kale *et al*. (2018).

1000-seeds weight (g)

Thousand seeds weight was significantly affected by planting date, planting density, variety and their interaction in 2022 and 2023 seasons (Table 2). The highest value was obtained from sowing date of April 10, plant density of 20 plant/m^2 and Bulkh variety, while the lowest value was obtained from sowing date of June 10, plant density of 40 plant/m^2 and Samangan variety in both seasons, (Table 3). Delay in the planting date causes decrease in the length of the vegetative and reproductive growth period and thus decreases the thousand seeds weight trait, in accordance of this result Alamsarkar *et al*. (2007) have reported significant effect of planting date on the 1000-seed weight of sesame. According of plant density, it seems that the reduction of plant population due to the decrease of competition between plants, environmental facilities such as space, water and plant nutrient are available to each plant in a larger amount, therefore, increasing of weight of seeds per plant, lead to increasing thousand seeds weight of sesame Aslam *et al*. (2015). On the contrary, Oloniruha *et al*. (2021) reported insignificant reduction in 1000-seed weight with increasing of plant population. In term of variety, the reason might be due to the genetic makeup of the variety, this result is in agreement with Golla, (2020) and Lakew *et al*. (2018), found that 1000-seed weight was affected by sesame varieties. Similar result was mentioned by Yılmaz (2022) and Sirisha *et al*. (2022) who reported that 1000-seeds weight affected by cultivar of sesame.

Seed yield (t/ha)

The analysis of variance showed that highly significant differences were found for the main effects of sowing dates, planting density and their interaction effect of sowing date × planting density × variety on seed yield in 2022 season whereas, in 2023 season highly significant difference was recorded only for the main effects of sowing date, plant density and their interaction (Table 2). The highest seed yield was obtained for Balkh variety with sowing date of April 10 and plant density of 40 plant/m^2, while the lowest seed yield was obtained for Baghlan variety with sowing date of June 10 and planting density of 20 plant/m^2 in 2022 season (Table 3). Similar result was finding by Monpara and Vaghasia, (2016), who reported that interaction between sowing dates and plant densities was significant for seed yield. In this study, seed yield decreased as the planting date was delayed from April 10 to June 10. This is in line with Alamsarkar *et al*. (2007) and Badran, (2009) In this study, it was found that reduction of plant density decreased the seed yield, but increasing plant density increase the seed productivity. Similar result was mentioned by Ozturk and Saman (2012) and Sangma *et al.* (2022) who reported that the highest plant population density led to increase yield productivity, may be due to the highest number of plants per area in closer row spacing or hills on row, could compensate that decreasing in the yield component of the plant such as the weight of 1000 seeds, number of capsules/plants.

Biological yield (t/ha)

Biological yield was significantly affected by interaction of sowing date × plant density × variety in 2022 season whereas, only the main effect of sowing date, plant density

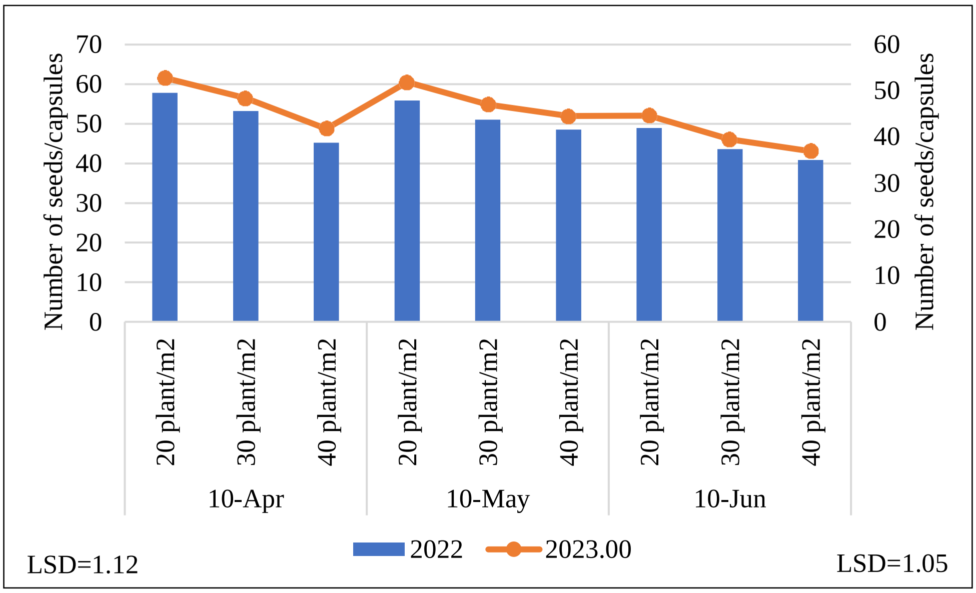

Fig 4: The effect of interaction between sowing date and plant density on number of seeds/capsules in 2022 and 2023 seasons.

and their interaction sowing date × plant density on biological yield was significant in 2023 season (Table 2). The maximum biological yield was recorded for Balkh variety with sowing date of April 10 and plant density of 40 plant/m^2, while the minimum biological yield was recorded for Baghlan variety with sowing date of June 10 and plant density of 20 plant/m^2 in 2022 season (Table 3). It seems that early planting date and higher plant population density lead to higher biological yield per unit area. This is in line with finding of Caliskan *et al*. (2004) and Anishetra and Kalaghatagi (2021) who concluded that biological yield per unit area was directly proportional to the ratio of crop growth rate, high population ensured early canopy coverage and maximized light interception, greater crop growth rate and crop biomass.

Harvest index

Harvest index was significantly affected by interaction of sowing date × planting density × variety in 2022 season and only the main effect of sowing date and plant density on harvest index was significant in 2023 season (Table 2), this is in line with El naim *et al*. (2010) and Ismaan *et al*. (2020), whereas the finding of Aghili *et al*. (2015) showed that the effect of cultivar on harvest index was significant, this indicated that the harvest index was mainly influenced by genetic factors rather than environmental and agronomic factors. The highest harvest index was obtained for Balkh variety with sowing date of April 10 and plant density of 40 plant/m^2, while the lowest harvest index was obtained for Baghlan variety with sowing date of June 10 and plant density of 20 plant/m^2 in 2022 season. Lakhran *et al*. (2015) revealed that different sowing dates did not show their significant influence on the harvest index of sesame plant. Increasing plant density from 20 to 40 plant/m^2 increases harvest index of sesame. Similar result found by Caliskan *et al*. (2004) pointed that greater harvest index observed with higher plant population density. In the contrast, El naim *et al*. (2010) found the low plant population had a higher harvest index than the high plant population.

Table 3: The effect of interaction between sowing date, plant density and variety on sesame traits in 2022 season.

Sowing date	Planting density	Variety	1000 seeds weight (g)	Seed yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
April 10	20 plant/m^2	Balkh	3.25	1.15	4.25	27.70
		Baghlan	3.10	1.25	4.25	29.41
		Samangan	3.05	1.25	4.35	29.41
	30 plant/m^2	Balkh	2.90	1.35	4.43	31.03
		Baghlan	2.80	1.43	4.50	32.32
		Samangan	2.75	1.50	4.50	33.31
	40 plant/m^2	Balkh	2.50	1.50	4.43	34.33
		Baghlan	2.55	1.43	4.43	32.32
		Samangan	2.45	1.43	4.00	32.32
May 10	20 plant/m^2	Balkh	3.00	1.00	4.00	25.00
		Baghlan	3.00	1.00	3.90	24.97
		Samangan	3.15	0.90	4.20	23.08
	30 plant/m^2	Balkh	2.65	1.20	4.30	28.57
		Baghlan	2.65	1.30	4.25	30.21
		Samangan	2.65	1.25	4.40	29.35
	40 plant/m^2	Balkh	2.45	1.40	4.50	31.79
		Baghlan	2.45	1.50	4.43	33.33
		Samangan	2.40	1.43	3.95	32.32
June 10	20 plant/m^2	Balkh	3.00	0.95	3.85	23.98
		Baghlan	2.90	0.85	4.00	22.07
		Samangan	2.70	1.00	4.20	25.00
	30 plant/m^2	Balkh	2.50	1.20	4.20	28.57
		Baghlan	2.45	1.20	4.25	28.54
		Samangan	2.35	1.25	4.35	29.41
	40 plant/m^2	Balkh	2.35	1.35	4.47	31.03
		Baghlan	2.30	1.47	4.40	32.83
		Samangan	2.25	1.40	4.25	31.79
	LSD (0.05)		0.104	0.117	0.368	1.876

CONCLUSION

From the results of the study concluded that sesame has the capacity to achieve high yield levels in the Samangan region in Afghanistan when sowing date and planting density are optimal. The result indicated that the main effect of sowing date, plant density and the interaction of them were highly significantly differed in yield related traits in both seasons, thus sesame with early planting date (April 10), high plant population (40 plant/m^2) was better in terms of seed productivity. However, there is still a large amount of research that needs to be done to truly find causative links between these management choices and reproductive development and yield potential for the crop in Samangan region. In addition, further management recommendations must be established to test the yield potential in these regions, including fertility levels, optimal rotational crops and development of region-specific crop models.

Conflict of interst

All authors declare that they have no conflict of interest.

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