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Effect of date of sowing and plant geometry on oil content of chia (*Salvia hispanica* L.)

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Abstract
The experiment was laid out in Factorial Randomized Block design assigning date of sowing (Factor A), plant geometry (Factor B) with three replications to assess the effect of date of sowing and plant geometry on oil content of Chia. The experiment was conducted at Experimental farm, Agriculture Research Station, Mandor-Jodhpur (Agricultural University, Jodhpur) in the year 2016-17. Factor A consisted of Four date of sowing viz., 25th October (D_1), 05th November (D_2), 15th November (D_3) and 25th November(D_4) and factor B consisted of four plant geometry viz., 30 cm x 30 cm (P_1), 45 cm x 30 cm (P_2), 60 cm x 45 cm (P_3) 90 cm x 45 cm (P_4). Data on oil content revealed 25th October as best date of sowing of Chia and proclaimed highest values for oil content (31.81 %). on the other hand plant geometry of 45 cm x 30 cm (P_2) also recorded highest values for oil content (26.05 %). The interaction effects due to date of sowing and plant geometry under study were not significant in respect of oil content of chia seed.

Keywords: Chia, date of sowing, plant geometry and oil content

Introduction
Chia (*Salvia hispanica* L.) is an annual plant belonging to the Lamiaceae family native to Mexico and Guatemala (Ixtaina *et al.*, 2008) [6]. Chia is also categorized under the super-division of Spermatophyte, and kingdom of Plantae. The crop can grow up to 1 meter tall and has opposite arranged leaves. *Salvia hispanica* produces white or purple flowers. Chia produces small flower (3-4 mm) with small corollas and fused flower parts that contribute to a high self-pollination rate. The seed colour varies from black, grey, and black spotted to white, and the shape is oval with size ranging from 1 to 2 mm (Bresson *et al.*, 2009) [3]. However, chia commercialized today is mainly black spotted, followed by a low but increasing percentage of white seeds (Ayerza and Coates, 2005) [2].

Chia is cultivated in Argentina, Australia, Bolivia, Colombia, Guatemala, Mexico and Peru. Chia has also been reportedly cultivated in Southeast Asia and naturalized in the Caribbean (Jansen *et al*., 1991) [8].

Chia seed is composed of protein (15 - 25%), fats (30 - 33%), carbohydrates (26 - 41%), high dietary fiber (18 - 30%), ash (4 - 5%), minerals, vitamins, and dry matter (90 - 93%). It also contains a high amount of antioxidants (Ixtaina *et al*., 2008) [6]. Recently, chia seed has become important for human health and nutrition because its Omega -3 fatty acid content promotes beneficial health effects (Vuksan *et al*., 2010) [17]. Chia is cultivated as a rich source of ω -3 fatty acids and for its high content of α-linolenic acid. Oil content of white seeds and black seeds of chia is about 33.8% and 32.7%, respectively (Suri S. *et al*., 2016) [16]. Yeboah (2014) [18] also reported that chia seed contains 35% oil. Chia oil contains one of the highest known concentrations of α - linolenic fatty acid, up to 67.8% (Ayerza and Coates, 2005) [2]. Chia has regained its popularity by becoming one of the main oil sources that contains high levels of polyunsaturated fatty acids (PUFAs).

Omega (ω) -3 and ω - 6 FAs are essential PUFAs. Alpha linolenic acid (ALA) and linoleic acid (LA) are the major long chain FAs belonging to the omega-3 and omega-6 groups, respectively. LA and ALA are required for structural integrity of cell membranes as well as being precursors for longer chain FAs (Mann & Truswell, 2007) [10]. Chia, which used to be the major food crop of the indigenous peoples of Mexico and Guatemala, is now widely cultivated and commercialized for its ω-3 α-linolenic acid (ALA) content and antioxidant properties. Today, its cultivation is not only limited to the Americas but is also extended to other areas such as Australia and Southeast Asia (Jamboonsri *et al*., 2012) [7].

Materials and Methods

The experiment was conducted at Agricultural Research Station, Mandor-Jodhpur. Geographically, Jodhpur is situated between 26º 15' N to 26 ^{0} 45' North latitude and 73º 00' E to latitude 73º 29' East longitude at an altitude of 231 meter above mean sea level. This region falls under agro-climatic zone I a (Arid Western Plains plain Zone) of Rajasthan. Factor A consisted of Four date of sowing viz., 25th October (D_1), 05th November (D_2), 15th November (D_3) and 25th November(D_4) and factor B consisted of four plant geometry viz., 30 cm x 30 cm (P_1), 45 cm x 30 cm (P_2), 60 cm x 45 cm (P_3) 90 cm x 45 cm (P_4).

The climate of Jodhpur is typically arid with hot dry summers. The average annual rainfall is about 367 mm (CV 52%) and bulk of it (85 to 90%) is received from June to September (*kharif* season) by the southwest monsoon. The normal time of onset of monsoon is the last week of June to first week of July, but weather aberrations are quite common with respect to late arrival and early withdrawal of monsoon that resulted dry spells and high temperature during *kharif* season. The other distinct climatic features of this region are low relative humidity (15 to 30%) with high wind velocity (30 to 40 km hour^{-1}), solar incidence (520 cal cm $^{-2}$), potential evapotranspiration (1843 mm year^{-1}) and wide range of maximum (24.6ºC in January to 41.6ºC in May) and minimum (9.6 in January to 27.7ºC in June) temperatures.

In order to know the physical and chemical properties of soil, the soil samples from 0-30 cm depth were drawn randomly from different spots of the experimental field and a representative composite sample was prepared which was analyzed to determine the physico-chemical properties of the soil. The values of the soil analysis along with methods used for determination are presented in Table 3.2. The analytical results revealed that the soil of the experimental field was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon (0.13%), low in available nitrogen (174 kg ha^{-1}) and medium in phosphorus (22.2 kg ha^{-1}) but high in available potassium (325 kg ha^{-1}).

Chia seeds were sown in plot on four different date of sowing and four levels of spacing. All the standard recommended cultivation practices were followed for cultivation of the crop including fertilization with 20 kg Nitrogen and 40 kg Phosphorus. After sowing of the crop, four irrigations were applied at branching, pre-flowering and seed formation and seed hardening stages for proper growth and development during the growing season.The obtained data was analysed for Factorial Randomised Block Design and result was interpritated for effects and interactions (Panse and Sukhatme 1989).

Results and Discussion

Data presented in the Table 1 and graphically depicted in Figure 1 and 2 showed significant (at 1 % level of probability) effect of date of planting and spacing on oil content of Chia. The oil content differed significantly due to date of sowing when crop was sown on 25thOctober, it produced significantly higher oil content (31.81 %) which was significantly superior to later sowing on 5th November (28.04 %), 15th November (21.73 %), and 25th November (17.50 %). Fatemeh *et al.* (2007) [5] reported similar results; early date of sowing gives more oil content.

The oil content differed significantly due to varying plant geometry. Plant geometry of 45 cm x 30 cm recorded significantly higher oil content (26.05%) than 90 cm x 45 cm (24.95 %), 60 cm x 45 cm (24.47 %) and 30 cm x 30 cm (23.61%). Similar results were found by Alemu (2017) [1], Mirjalili & Poorazizi (2014) [11], Sarma and Sarma (2014) [15], Raina *et al.* (2013) [13], Daneshian *et al.* (2011) [4] and Kabur (1997) [9].

The interaction effects due to date of sowing and plant geometry under study were not significant in respect of oil content of chia seed. Salim *et al.* (2014) [14] also found similar results.

Table 1: Effect of date of sowing and plant geometry on oil content (%) of chia

Treatment	Oil content (%)
Date of sowing	
D_1 (25th October)	31.81
D_2 (05th November)	28.04
D_3 (15th November)	21.73
D_4 (25th November)	17.50
SEm ±	0.30
CD (P = 0.05)	0.87
Plant geometry	
P_1 (30 cm x 30 cm)	23.61
P_2 (45 cm x 30 cm)	26.05
P_3(60 cm x 45 cm)	24.47
P_4 (90 cm x 45 cm)	24.95
SEm ±	0.30
CD (P = 0.05)	0.87
Interaction	
SEm ±	0.60
CD (P = 0.05)	NS

Conclusion

Oil content (%) was found maximum with D_1 (25th October sowing) which was significantly higher over rest of dates of sowing. Among plant geometry, P_2 (45 cm x 30 cm) recorded significantly higher Oil content (%).

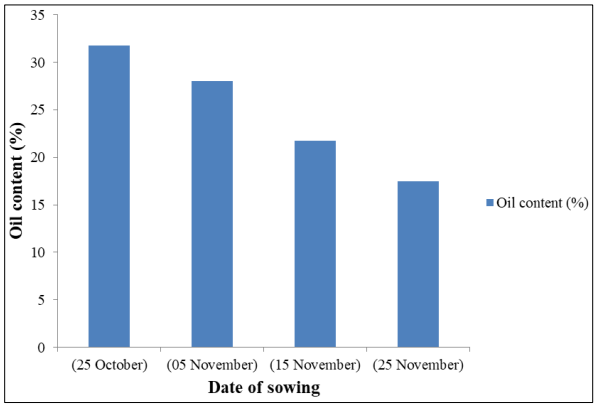

Fig 1: Effect of date of sowing on oil content of chia

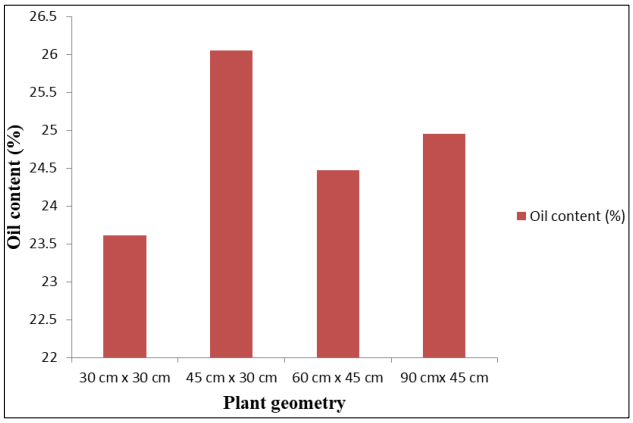

Fig 2: Effect of plant geometry on oil content of chia

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