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Climatic impact on physical properties, oil and protein content of two sesame (*Sesamum indicum* L.) varieties

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Abstract
In this study experiments was conducted to evaluate the effect of climate on sesame. Sesame (*Sesamum indicum* L.) is one of the world's most imperative oil seed crops, impact of climate change mainly rainfall and temperature which is one of the foremost concerns. The objective of this work was to evaluate that effects of present climate on oil percent and protein percent as well as the morphology in the two Sesame seed PRACHI (Black seed) and HT-2 (White seed) based on the obtained results.
The experiment was conducted in randomized block design with three replications during two successive *kharif* seasons 2014 and 2015. The monthly temperature and rainfall data were collected from metrological department of JNKVV, Jabalpur. The results showed that monthly temperature and rainfall had significantly effect on number of branches/plant, seed weight, seed yield/plant, oil content, protein content, carbohydrate content, oxalic acid content as well as free fatty acid.

Keywords: *Sesamum indicum*, oil percent, protein percent, seed morphology, oxalic acid and fatty acid

Introduction

Sesame (*Sesamum indicum* L.) is usually planted in arid and semi-arid regions of the world. The major producing countries are China, India, Myanmar and Sudan (Khidir *et al.*, 2007) [18]. In the sudan, the crop is grown under rainfed conditions (300-800 mm), in an area of 3 million feddans, which represents 13% of the world production (Khidir *et al.*, 2007) [18]. Sesame crop has early origins in East Africa and India (Bedigian, 2003) [8]. It had earned a poetic label "Queen of oilseeds" because seeds have high quality poly-unsaturated stable fatty acids which offer resistance to rancidity (Bedigian *et al.*, 1986) [9] It is rich in polyunsaturated fatty acids (omega-6-fatty acids) (Toma and Tabekhia, 1979) [29]. The oil seed is renowned for its stability because it strongly resists oxidative rancidity even after long exposure to air (Global Agri Systems, 2010) [13]. The oil fraction shows a remarkable stability to oxidation. This could be attributed to endogenous antioxidants namely lignins and tocopherols (Lee *et al.*, 2008) [11, 20].
Sesame is excellent source of oil 57-63% (Uzun *et al.*, 2003) [30], Protein 23-25% (Anilakumar *et al.*, 2010), Carbohydrate 20-25% and ash 5-6 % (Salunkhe *et al.*, 1992) [26]. Oil contains vitamins A, B- B_1, D and E (Ojiako *et al.*, 2010) [24]. Sesame seed contain methionine 2.85 to 3.85%**,** tryptophan and sulfur containing amino acids and limited in lysine. Seeds contain significant amounts of oxalic acid (2.5%) and phytic acids 5% (Kapadia *et al.*, 2002) [19]. Additionally, fat of sesame seeds contain about 2.25 times as much energy as the equal amount of carbohydrates from feed grains or forages (Choi *et al.*, 2008) [11]. Sesame contains minerals Cu, Ca. P, Fe, Mg, Mn and Zn (Hasan *et al.*, 2000) [14]. Copper provides relief for rheumatoid arthritis. It is established that Sesame seeds contain three times more calcium than a comparable measure of milk. Calcium helps prevent colon cancer, osteoporosis, and migraine while magnesium supports vascular and respiratory health systems zinc is known to promote health (Alpaslan *et al.*, 2001) [3].
Sesame oil is known for its high nutritional value and is unique in containing high levels of the furofuran lignans (methylenedioxyphenyl compounds) such as sesamin, sesamol, sesamolin and tocopherols substances, Among the bioactive components in sesame seeds are IP-6 (Phytate; one of the most powerful antioxidants yet found), lignans, tocopherols, lecithin, myristic acid and linoleate have been identified as the major antioxidants which responsible for the resistance of oxidative deterioration of sesame seeds and oil (SiHyung *et al.*, 2010) [27].
Agricultural economics is influenced by the weather.

Indian economy primarily depended on agricultural an activity which in turn is dependent on climate factors such as rainfall and variability of temperature beside varietal genetics, soil fertility, and crop management factors The performance of the crop is affected by factor such as climatic, nutrients, water availability, inter and intra- specific, completions pest and disease as well as socio-cultural and socio-economic factor among other things. (Adeyema and ojo, 1991).

The environment is one such natural factor which plays an important role in determining the yield. Changes in yield component may be a result of plant's response to stress at various stages of plant growth and development (Adams, 1967) [2]. In other hand, Mohamed studied the impact of weather change on Sudanese cereal grains and cash crops such as sesame, and groundnut and reported a higher impact of rain on yields compared to increased temperatures (Mohamed, 2011) [21]. Despite recent technological advancements in crop improvement methods, weather remains a critical factor that determines the agricultural productivity. Jones and Thornton reported the severe impacts of change on rainfall and temperature on yields of staple crops such as maize, millet, sorghum, sesame and peanut. In other hand, higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation (Jones *et al.*, 2003) [17].

In India sesame is grown in rain-fed crop. The total area of production varies from one year to another year, mainly due to fluctuations of rainfall and temperature. The total area cultivated in India is about 19.01 lakh hectares with 8.6 lakh tones production and earns rupees 2880 crore through export. It is grown in all the seasons and being a sort duration crop, fits well in to various cropping systems. In India the volume of research related to sesame crop climate relation is relatively very small in comparison with other oil seed. The objective of present work is to study the effect of monthly temperature and rainfall on various parameters of sesame.

Materials and Methods

The present study was consisted with field experimentation and several analytical works in the laboratories. Field experiment was conducted on *kharif* season to observe its growth development and yield as influenced by monthly temperature and rainfall. The materials used and methodologies employed during the course of investigation on the field and laboratories are concisely described in this chapter.

Climate: Jabalpur is situated at 23'90" N latitude and 79' 58" E longitude at an altitude of 411.78 meter above the mean sea level it falls under subtropical climatic conditions which is characterized by the features of hot dry summers and cool dry winters. The 10 years mean annual rainfall is mainly receives during the period between end of June to end of September. The rainfall is often erratic and ill distributed along with on occasional long dry spells or frequent heavy rainy days during rainy seasons. There is possibility of occasional and little rainfall during rest period of the year. The maximum and minimum temperature ranges between 24˚C and 45˚C and 4˚C to 32˚C, respectively within a year in some of the years, maximum temperature reaches as high as 45˚C in the month of may or June, while minimum temperature falls 2˚C down to a limit of 4˚C during end of December or January months.

Weather Condition: The present investigation was conducted during *kharif* seasons. Monthly data were be recorded from July to November, ranges between 31.2˚C to 20.66˚C in 2014 and 31.72˚C to 20.92˚C in 2015 respectively, The total rainfall received from July to November during the crop season was 798.8 mm in 2014. Which was equally distributed in 46 rainy days and in year 2015 received rainfall is 929.2 mm. which was equally distributed in 36 days? Therefore the crop did not suffer due to adverse effect of rains on the sesame weather became clear and dry immediately after rains. As a whole weather conditions prevailed during the crop season were almost conductive for proper growth development and yield of sesame crop.

Experimental Site: Field experiment was conducted in the demonstration farm faculty of agriculture university of Jabalpur at research form project coordinating unit (sesame and niger) J.N.K.V.V Jabalpur (M.P.) during *kharif* season 2014 -2015. All physical facilities are available in the research form to carry out the field experiment. The analytical works were done in the laboratory of project coordinating unit (sesame and niger) J.N.K.V.V. Jabalpur.

Experimental Layout: Sowing: Sowing was on 15 July 2014 and 15 July 2015 the crop was sown on the top of the ridge 70 cm apart in holes at a spacing of 15 cm.

Meteorological Data: During the period of this work different weather parameters viz. temperature rainfall of Jabalpur during entire crop season was recorded from the meteorological observatory Agriculture Engineering collage J.N.K.V.V. Jabalpur. These data are presented in table 2 and also illustrated graphically through the figure 2.

Physical Properties: Electronic Digital Venire Caliper and Caliper Gauge for the dimensions of seeds, length, width and Seed weight was measured with the help of a single pan electric balance (Afcoset, ER 180 A, Japan). The mean values of seed dimension parameters were obtained from a set of n=10 seeds in triplicates of each colors (IPGRI, 2004) [15]. Digital dial caliper: Dimension (Length, width, and thickness) of sesame seeds were determined considering the three axes xx, yy, and zz. A digital caliper reading up to 15 cm was used. Its accuracy is 0.05mm.

Growth Attributes: A sample of five plants was taken, at random from each experimental subplot for measure the following growth parameters.

1. **Number of branches/plant** - Number of branches was determined by counting the number of primary reproductive branches.
2. **Capsule number per plant** – numbers of properly filled capsules was recorded at physiological maturity.
3. **1000-seed Weight** – one thousands filled seeds were taken randomly after shad drying and weighted in gram to assess the boldness of seeds
4. Seed yield per plant
5. **Seed yield (kg/ha)** – seed yield is dependent character which is sum total of positive and negative effects of different yield attributing traits, seed yield per plant was recorded and converted in to seed kg/ha by multiplying it with conversion factor which is calculated by following formula = 10 / net plot size.

Yield Attributes: The final grain yield (t/ha) was determined as follows:

Grain yield (t / ha) = Grain weight (t) of plot X 10000.

Biochemical Analysis
Firstly before analysis collected sesame seed from J.N.K.V.V. Jabalpur experimental field and prepared powdered later the samples was used for protein, oil, fatty acid, oxalic acid and carbohydrate.

Estimation of oil in seed sample
The oil content of seeds of each plot was estimated by using NMR equipment (*Oxford Analytical Make*) in the laboratory, Project Coordinating Unit (Sesame and Niger), JNKVV, Jabalpur. A composite seed sample of each treatment was taken to analyze the oil content (%).

Estimation of free fatty acid in seed sample (Determined by the standard AOCS method 1980)
Oil content (%) Procedure (Described by Pearson, 1976)
Oil per cent was determined by Soxhlet Extraction Method. Oil from a known quantity of the seed was extracted with petroleum ether. Then, it was distilled off completely, dried, weighed and the per cent oil was calculated.

$$\text{FAT \%} = \frac{W2 - W1}{W} \times 100$$

Take 1 gm. oil in 20 ml natural solution of 95% ethanol boiled it and titrated with 0.1 N alkali KoH, presence of phenolphthalein indicator. The titrate values with the appearance of the light purple color was recorded and calculate FFA (%) was calculated by using the following formula:

$$\text{FFA\%} = \frac{2.303 \text{x Normality of KOH x Titrate value}}{\text{Weight of oil sample (g)}}$$

Estimation of protein by micro kjeldahl method
Plant proteins have been divided into two groups, the reserve protein of grain and the functional protein of the vegetative parts of the plant.
Multiplying the nitrogen content value of grain or straw with 6.25 will give the crude protein content, which also includes non-protein nitrogen. To get true protein content, deduce the non-protein nitrogen from crude protein content and then multiplying with the factor. The crude protein content (%) wheat grain was worked out by following formula (A.O.A.C. 1965)
Crude protein % = N content (%) X 6.25 (as a constant factor).

Oxalic Acid: - oxalic acid content of the sesame seed sample was determined according to titration method as described by (AOCS, 1980)

$$\text{Oxalic acid \%} = \frac{6.303 \text{ X normality of } KMnO_4 \text{ X volume of } KMnO_4}{\text{Weight of seed sample (gm.)}}$$

Carbohydrate: - carbohydrate content of the sesame seed sample was determined according to an-throne method as described by (AOAC, 1990)

$$\frac{\text{Absorbance of unknown}}{\text{Concentration of unknown}} = \frac{\text{Absorbance of standard}}{\text{Concentration of standard}}$$

Results and Discussion
Impact of climate on cultivars and their interaction on physiology of sesame and seed oil, protein content of sesame crop. In this study we take two sesame cultivars PRACHI and HT-2. PRACHI are black color seeded shape in oval with convex side, smooth+ rough texture length of seed showed 2.61±0.078, width is 1.81±0.078 and thickness is 0.87±0.048. While HT-2 is white color seeded oval with convex side shape and smooth in texture, length 2.95±0.35, and 1.85±0.05 width and 0.84±0.07 thickness. Sesame seed size is parallel with the study by (Harmond *et al.*, 1965) lengths 2.5, Width 1.65, Thickness 0.94 Harmond reported that the size of an object determines how much space can be occupied and it can be described in terms of length, width and thickness. They added also that the size is also important in selection or design of disks for precision planting and in proper adjustment of clearances and screen openings in combining.

Table 1: Physical properties of sesame genotype

Varieties	Color	Shape	texture	Mean Length (mm) µ±S.D n = 10	Mean Width (mm) µ±S.D n = 10	Mean Thickness (mm) µ±S.D n=10
HT-2	White seed	Oval with convex side	Smooth	2.95 ± 0.35	1.85 ± .05	0.84 ± .07
PRACHI	Black seed	Oval with convex side	Smooth + rough	2.61 ± .078	1.81 ± .078	0.87 ± .048

Table 2: Monthly rainfall and temperature in the year of 2014-2015

Month	Temperature (°C)				Rainfall (mm)			
	2014		2015		2014		2015	
	Maxi. Temp.	Mini. Temp.	Maxi. Temp.	Mini. Temp.	Maxi. Rainfall	No. of rainy days.	Maxi. Rainfall	No. of rainy days
July	32.7	24.9	31.6	24.2	316.5	18	413.2	16
August	31.0	24.3	30.9	23.8	241.7	11	366.6	12
September	31.5	23.1	32.4	23.0	199,0	14	109.4	07
October	31.2	18.8	33.4	18.4	41.6	3	40.0	01
November	29.9	12.2	30.3	15.2	0.00	0	000	00
Average between July to November	31.26	20.66	31.72	20.92	798.8	46	929.2	36

Table 3: detail of released both sesame varieties by different states in India

S. No	Varieties Name	Year Of Identification	Originating institute	Svrc/Cvrc S.O. No. & Date	Pedigree	Recommended Regions/Area	Days To Maturity	Oil Content (%)	Average Yield (Kg/Ha)	Salient Features/ Other Information
1	PRACHI	OUAT, Bhubaneswar (Orrisa	2004	CVRC-161 (E) 4-2-04	Mutant of B-67	*Kharif*, summer, Orissa	85-90	42-44	650-750	White seed, tolerant to phyllody and lef curt
2	HT-2	Oilseed section, CCS, HAU, Hissar (Haryana)	2012	CVRC-SO, 952 (E) 13/10-4-13) (F. No. 3-21-2012-SDIV)	HT-1 X HT 15	Haryana, Punjab, HP, Delhi and J & K	85-90	48-50	600-650	White hold seed, tolerant to bacterial blight

Table 4: Branch number per plant, capsule number per plant, seed number per capsule, 1000-seed weight, seed yield per plant Kg/ha in both cultivars

Varieties	No. of offshoot/plant		Involucres number/plant		1000-seed sinker		Seed sequel/plant	
	2014	2015	2014	2015	2014	2015	2014	2015
HT-2	2.1±0.07	2.5±0.11	54.7±1.08	55.7±1.26	2.57±0.1	2.68±0.1	6.53 ±1.1	7.39.1±1.4
PRACHI	4.3±0.10	4 ±0.24	72.42±0.9	68.85±1.001	2.71±0.03	2.71±0.05	10.5±1.2	11.1±2.5

Table 4: biochemical content obtained from both cultivars of sesame

Varieties	Oil content (%)		Protein content (%)		Carbohydrate content (%)		Free Fatty acid (%)		Oxalic acid (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
HT-2	46.7±1.9	48.4±0.4	16.3±0.1	18.4±0.09	18.5±0.09	19±0.8	2.1±0.3	1.8±0.3	1.8±0.1	1.7±0.1
PRACHI	47.7±1.02	49.4±0.2	16.8±0.1	19.0±0.8	17.9±0.1	17.6±0.1	1.2±0.2	0.8±0.2	0.95±0.02	0.8±0.1

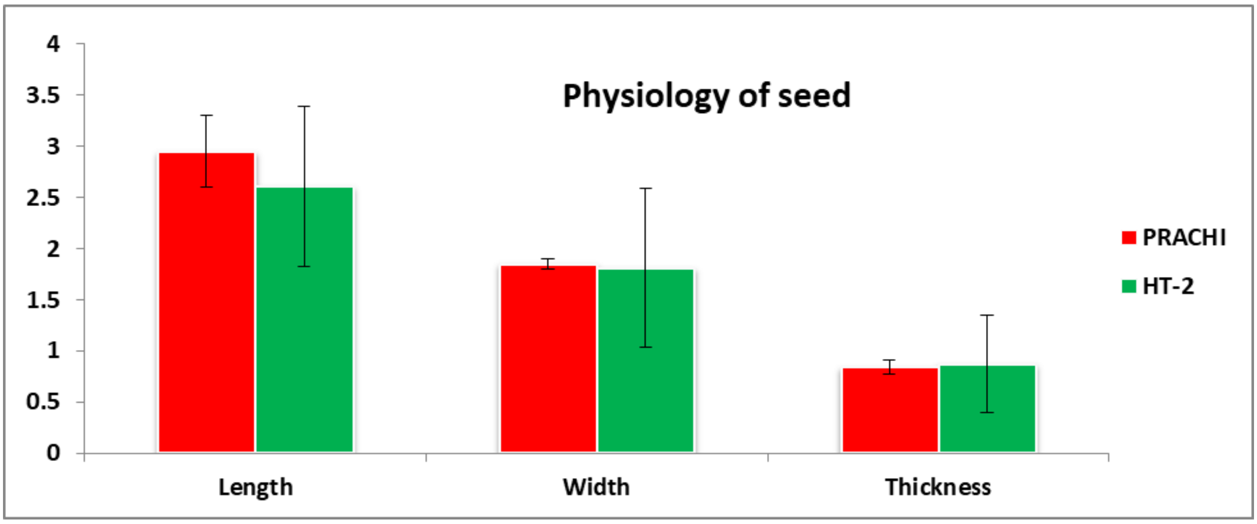

Fig 1: Physiology of seed Length, Width, Thickness of sesame seed

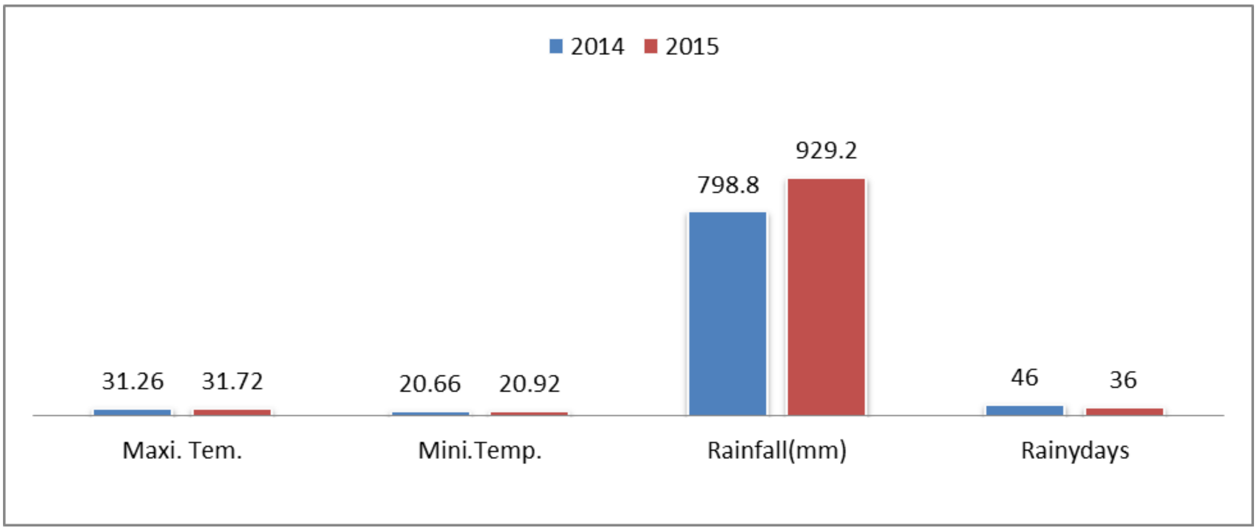

Fig 2: Monthaly rainfall and teampreture during July to November of 2014 – 2015

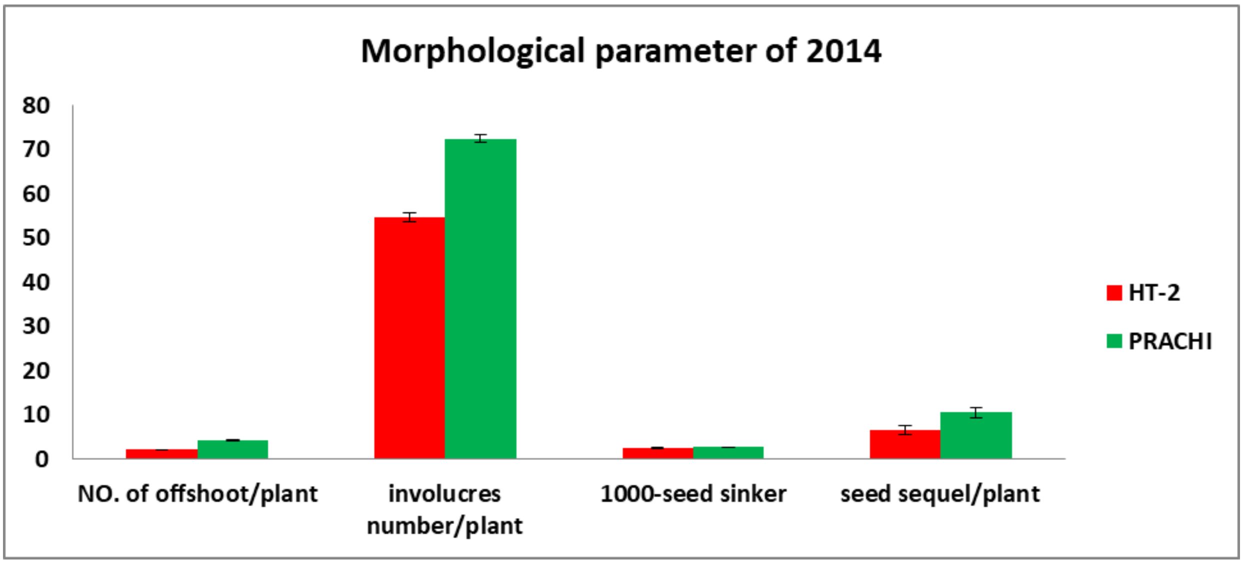

Fig 3: Effect of climate on morphological parameters of 2014 in both sesame cultivars.

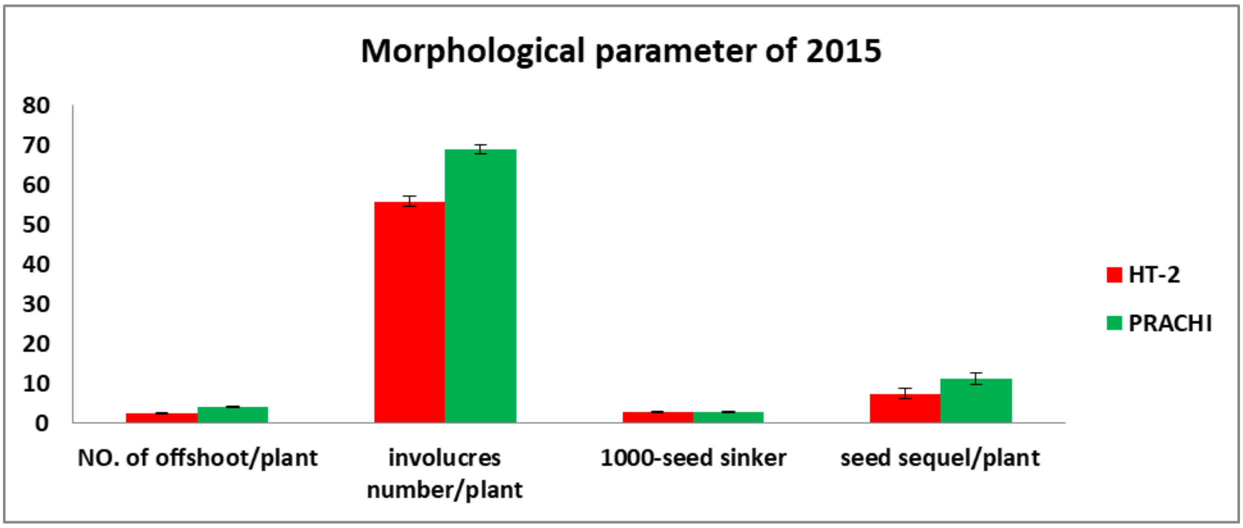

Fig 4: Effect of climate on morphological parameter of 2015 in both sesame cultivars.

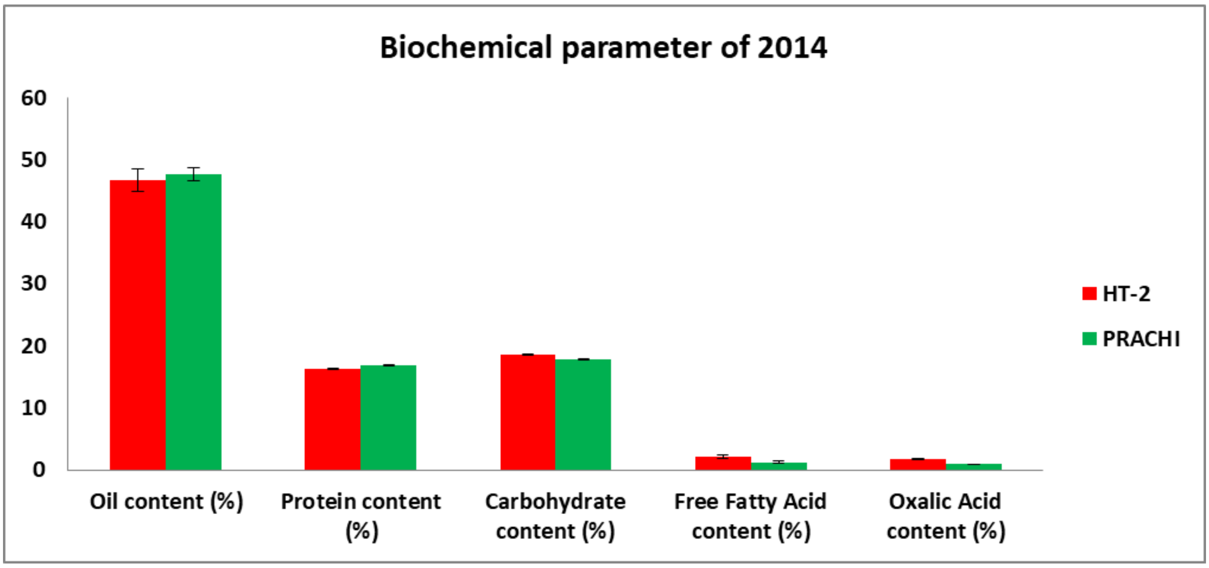

Fig 5: Effect of climate on biochemical parameters of 2014 in both sesame cultivars.

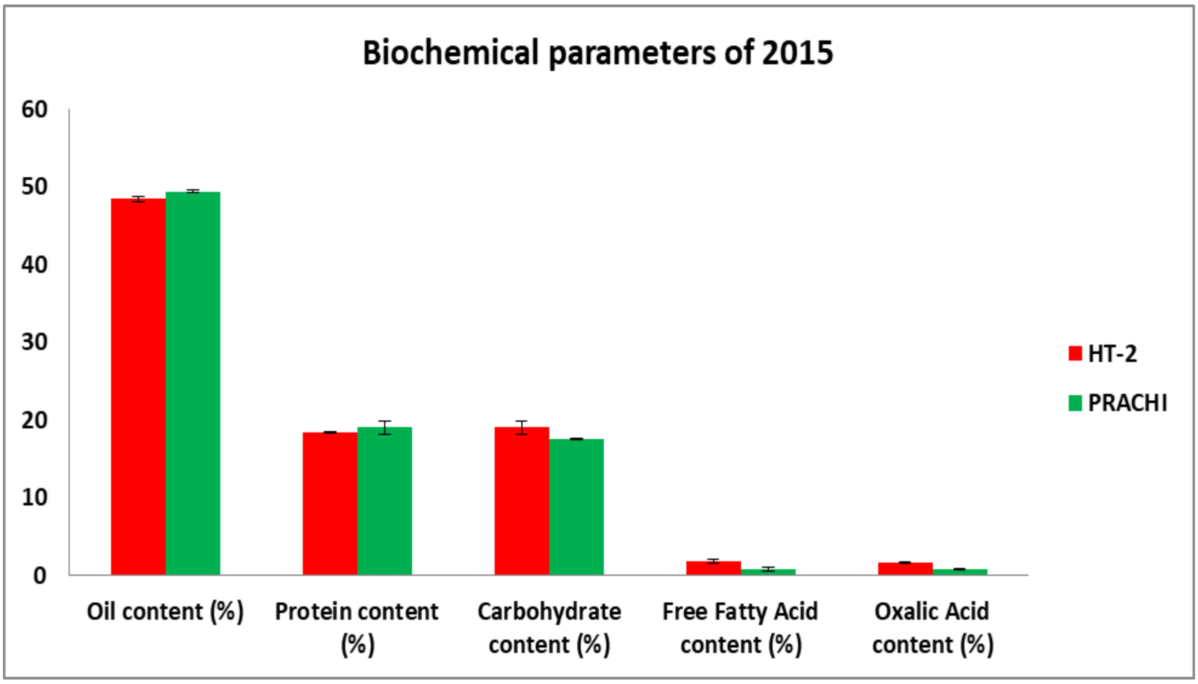

Fig 6: Effect of climate on biochemical parameters of 2014 in both sesame cultivars.

The offshoot number/plant in our study varied between 2.1±0.07 to 4±0.24 (table-4) which is similar to the ranged from 2.40 to 4.20 in the study carried out in sudan by (Mahdi *et al.*, 2007) [12]. The involucres number per plant which is very significantly for crop yield varied between 54.7±1.08 to 72.42±0.85 among both cultivars. The result obtained by (Yilmaz *et al.*, 2005) ranged from 73.68 to 97.68. The possibility for variation among both cultivars regarding that involucres number have been attributed to the adaptation to the length of day and directly related to the flower number per plant, which can be seriously affected by the climatic conditions (Söğüt, 2008) [28]. Thus 1000 seed sinker ranged from 2.57±0.10 to 2.71±0.05 (table-3) these results are consistent with the work reported by (Yilmaz *et al.*, 2005).

Seed sequel/plant showed variation among both cultivars between 6.53±1.1 to 11.1±1.5 (table-4) this result were consistent by previous works (Baydar, 2005) [7].

The variability in biochemical composition and oil percent recorded among the genotypes in the present study agree with reports of other researchers in sesame, there was however differences in the values between their reports and what were in this study.

The economic importance of sesame is determined by the quantity of oil contains. The result also indicated that seed oil of PRACHI is high than the HT-2 cultivars. The oil content ranged from 46.68±1.0 to 49.43±0.22 (table-5) respectively. The oil content of some cultivars in Anotaly a located in the Mediterranean Region of Turkey was reported to be range of 43.42 to 49.47 % by (Yilmaz *et al.*, 2005).

The mean protein content of 18.85 is less than mean values of 24.63 and 21.78 reported by (Borchani *et al.*, 2010) [10]. The highest value of 19.0 (table-5) recorded from PRACHI was however close to these means. Protein is very important in human nutrition and is one of the nutrients that are frequently low in plant proteins.

The oxalic acid of both sesame cultivars showed variation between 0.78 ±0.06 to 1.78±0.10 obtained in this study. This is close to 1.64 reported by (Borchani *et al.*, 2010) [10] According to (Jonson *et al.*, 1979) an unusual feature of sesame is that is generally contains 2to 3 % oxalic acid which is primarily in the hull dehulling improves the nutritional and flavor characteristic.

The carbohydrate content showed variation among both cultivars 17.56±0.12 to 19±0.81 is also low when is compared with the reported by (Ogbonna *et al.*, 2013) [22].

Free fatty acid of both sesame cultivars varied between 0.8±0.2 to 2.1±0.3 (table-5) which is high when compared with the reported by (Ogbonna *et al.*, 2013) [22].

The mean differences in the biochemical and physiological attributes between the two years may be attributed to the fact that the variation in weather factors in the two years was not sufficient enough to cause significant effect moreover the rainfall and temperature values recorded for the two years were within the range reported to be suitable for sesame production (Olowe 2007) [23].

Conclusion

In the present study, the morphological and chemical compositions of two sesame cultivars, cultivated in Jabalpur, (M.P.) were determined and compared. Regarding that physiological properties, the populations showed variations. Consequently fatty acid and carbohydrate, while Crude oil values are relatively closer to each in all sesame populations and protein content was obtained due to the fact that there is no soil fertilization and cultivation of sesame in this region is not made under irrigated condition. Finding of these experiment confirm that there is potential for sesame cultivation during the *kharif* season. Cropping in Jabalpur for sustainable sesame production Rainfall 929.2 mm and temperature 31.72˚c is recommended annually for high oil yield of sesame in Jabalpur HT-22. gave highest oil yield per unit area and high protein content type among the genotypes tested in the study area. This will be helpful for the farmer of Jabalpur region.

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