*Original Research Article*

Study on agrometeorological indices, heat use efficiency and phenothermal index of summer groundnut cultivars in South Saurashtra Agro-climatic Zone of Gujarat

ABSTRACT

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| **Aims:** To study the agrometeorological indices, heat use efficiency and phenothermal index of summer groundnut cultivars  **Study design:** Strip Plot Design  **Place and Duration of Study:** Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh  **Methodology:** The experiment contained three replication and twelve treatment combinations, where horizontal plot consisted of four different sowing dates *viz.,* D1 : 4th SMW, D2 : 6th SMW, D3 : 8th SMW and D4 : 10th SMW and vertical plot consisted of three different groundnut varieties *viz.,* V1 : GJG-31, V2 : GG-34 and V3 : GG-37. The study assessed several agrometeorological indices *viz.,* Growing Degree Days (GDD), Photothermal Unit (PTU), Heliothermal Unit (HTU), Hygrothermal Unit-I (HgTU-I) and Hygrothermal Unit-II (HgTU-II). The study also evaluated the Heat Use Efficiency (HUE) and Phenothermal Index.  **Results:** The study also evaluated the Heat Use Efficiency (HUE) and Phenothermal Index. The results showed 4th SMW sowing time takes the highest GDD (2230 ℃ day), PTU (27426 ℃ day hrs.), HTU (21579 ℃ day hrs.) and HgTU-I (151772 ℃ per cent) while 10th SMW sowing time takes highest HgTU-II (54048 ℃ per cent). HUE is highest in 6th SMW sowing time (1.16 kg ha-1 day-1) and Phenothermal Index is highest in 10th SMW (19.94 ℃ day hrs./day). Among the varieties, GJG-31 variety takes lowest GDD (2107 ℃ day), PTU (26226 ℃ day hrs.), HTU (20082 ℃ day hrs.) and HgTU-I (142443 ℃ per cent), HgTU-II (48686 ℃ per cent)and Phenothermal Index (17.99 ℃ day hrs./day). GJG-31 have the highest heat use efficiency (1.1 kg ha-1 day-1).  **Conclusion:** Based on this experiment it can be concluded that the GDD, HTU, PTU and HgTU-I decreased with delay in sowing and it was highest in 4th SMW. The highest HgTU-II and phenothermal index was observed in 10th SMW. HUE was found highest in the 6th SMW. Among the varieties, GJG-31 variety takes lowest agrometeorological indices and Phenothermal Index to reach the maturity respectively and had the highest HUE. |

*Keywords: Summer groundnut, Agrometeorological indices, Heat Use Efficiency, GJG-31*

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume crop which belongs to family *Leguminosae* and have its origin in South America. It is a major oilseed of tropical and subtropical countries. It is commonly known as peanut, earthnut, monkey nut and goobers. It is the 13th most important food crop and 4th most important oilseed crop of the world (Kumar *et al.*, 2017). Groundnut kernels are an excellent source of plant protein, which is nearly about 27 to 33 per cent and contain 45 to 50 per cent oil, as well as essential minerals, carbohydrates and vitamins. They play an important role in the dietary requirements for poor women and children and haulms are used as livestock feed. Groundnut oil is composed of mixed glycerides and contains a high proportion of unsaturated fatty acids *viz.,* oleic acid (50 to 65 %) and linoleic acid (18 to 30 %) (Young, 1996). The by-products of this crop like haulm and cake have good nutritive value. The groundnut cake obtained after groundnut oil extraction is rich in protein and considered as valuable organic manure and animal feed, which contains 7 to 8 per cent N, 1.5 per cent P2O5 and 1 per cent K2O. Some industrial products like paints, varnishes, soap and lubricating oils are also manufactured from groundnut. In India, total area under groundnut cultivation was 4.7 million hectares and total production was 10.2 million tonnes with productivity of 2163 kg/ha during the year 2023-24 (DA&FW, 2024a). Among the major groundnut growing states in India, Gujarat ranks first in area and production with area of 1.7 million hectares and production of 4.6 million tonnes. Gujarat also ranks first in productivity with yield of 2739 kg/ha (DA&FW, 2024b). Plant development and growth are complex responses to a variety of agrometeorological factors. Crop production in a given location is influenced by a number of factors, the most important of which is the weather. Temperature is the prime weather variable which affects plant life. Temperature is also one of the primary microclimatic factors driving the rates of plant growth. Plant has a definite temperature requirement before they attain certain phenological stages. Heat unit concept is the agronomic application of temperature effect on plant, which has been employed to correlate phenological development in crops and to predict maturity dates. Plants need a certain amount of heat to progress from one stage of their life cycle to the next, such as from emergence to leaf development. The accumulation of heat over time, according to research provides a more accurate physiological approximation than counting calendar days. Identifying meteorological suitable time of sowing for summer groundnut is important to have proper growth and development of plants. Different heat indices based on air temperature, such as growing degree days (GDD), photothermal units (PTU), heliothermal units (HTU), Hygrothermal Units (HgTU) and phenothermal index have been utilized to explain variations in phenological patterns and growth parameters. Measuring heat use efficiency (HUE) can help us determine how well a crop can produce yields in various growing conditions (Kingra and Kaur, 2011). In this study, our goal is to determine the best time to plant summer groundnut, how much heat they need and how efficiently they use that heat to grow.

2. material and methods

The experiment was conducted in C-6 plot of Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India (21.5°N latitude and 70.5°E longitude and 60 m above the mean sea level) during summer season of 2024. This site is located in the South Saurashtra Agro-Climatic Zone of Gujarat. The experimental field has an even topography with a gentle slope having good drainage. The soil samples were taken randomly from experimental plot to a depth of 0-15. The soil was clayey in texture, medium in organic carbon (0.58 %), medium in available phosphorus (29.6 kg/ha) and available potash (224 kg/ha) with average nitrogen (247 kg/ha). Its pH was alkaline (8.31) and low in soluble salts. The experimental design followed a strip plot design with four different sowing dates as horizontal plot treatments and three groundnut varieties as vertical plot treatment with three replications. The treatments consisted of four sowing dates : D1 : 4th SMW, D2 : 6th SMW, D3 : 8th SMW and D4 : 10th SMW and three varieties: GJG-31, GG-34 and GG-37. The recommended dose of nitrogen, phosphorus and potassium (N: P2O5: K2O @ 25:50:50 kg/ha) was applied through urea, DAP and MOP. Entire dose was applied to all the plots as basal dose in furrow prior to sowing. The seed were treated with fungicide Vitavex powder (Carboxin 37.5% + Thiram 37.5% WS) @ 3 g/kg of seed mixed properly before sowing. The seeds of groundnut varieties were sown at the distance of 45 cm between the rows @ 120 kg/ha. The first irrigation was given just after sowing and remaining irrigations were given as and when required by the crop. Weed management was done by hand weeding and interculturing at 30 and 45 DAS respectively. The crop experienced iron deficiency which was controlled by application of 100 g ferrous sulphate with 10 g citric acid in 10 L of water. The crop was also infested by sucking pest at vegetative stage which was controlled by application of Rogor (Dimethoate 30% EC) @ 2 mL/L. The harvesting of the crop was done at physiological maturity manually. Weather parameters *viz*., maximum temperature (Tmax), minimum temperature (Tmin), Relative humidity (RH I & RH II), Bright sunshine hours (BSS) were recorded at the agrometeorological observatory located near the experiment field. The  
agrometeorological indices *viz*., Growing Degree Days (GDD), Photothermal Unit (PTU), Heliothermal Unit (HgTU I & II) and Heat Use Efficiency (HUE) and Phenothermal Index were calculated by following formulas using base temperature of 10 ℃ (Lavand, 2012).

GDD = ∑ (Tmax+ Tmin)/2 – Base temperature

PTU = GDD × Maximum possible bright sunshine hours (N)

HTU = GDD × Actual bright sunshine hours (n)

HgTU-I = GDD × RH-I

HgTU-II = GDD × RH-II

HUE = Seed yield / Accumulated GDD

Phenothermal Index = Accumulated thermal units during a phenophase / duration of

phenophase

3. results and discussion

**3.1 Agrometeorological Indices**

**3.1.1 Growing Degree Days (GDD)**

The data pertaining to accumulated GDD in different treatments is presented in the Table 1. In the sowing time, the GDD accumulation was highest in 4th SMW (2230 ℃ day) than other sowing time. The minimum GDD was accumulated in 10th SMW sowing time (2101 ℃ day). Among the varieties, GJG-31 variety accumulated lowest GDD (2107 ℃ day) and GG-34 had accumulated the highest GDD (2149 ℃ day). The GDD accumulation was highest in 4th SMW due to longer duration of crop growing period and lowest in D4 sowing due to forced maturity caused by increase in temperature. The decrease in GDD may be due to decrease in the maturity period of the groundnut. These findings are in agreement with Mote and Pandey (2017), Dodiya (2022), Kumar *et al.* (2022), Limbasiya (2022), Yadav *et al.* (2023) and Yadavrao *et al.* (2023).

**3.1.2 Photothermal Unit (PTU)**

The photothermal unit under various sowing time and varieties is presented in the Table 1. In the sowing time, the photothermal unit was highest in 4th SMW (27426 ℃ day hrs.) than other sowing time. The minimum photothermal unit was accumulated in 10th SMW sowing time (26851 ℃ day hrs.). Among the varieties, GJG-31 variety accumulated lowest photothermal unit (26226 ℃ day hrs.) and GG-34 had accumulated the highest photothermal unit (28619 ℃ day hrs.). The photothermal unit also decrease with delay in the sowing due to variation in mean daily temperature that prevailed during the growth phases and late sown crop completed the life cycle earlier than the previous sowings due to increase in temperature. These findings are in agreement with Mote and Pandey (2017), Dodiya (2022), Kumar *et al.* (2022), Limbasiya (2022), Yadav *et al.* (2023) and Yadavrao *et al.* (2023).

**3.1.3 Heliothermal Unit (HTU)**

The heliothermal unit under various sowing time and varieties is presented in the Table 1. In the sowing time, the heliothermal unit was highest in 4th SMW (21579 ℃ day hrs.) than other sowing time. The minimum heliothermal unit was accumulated in 10th SMW sowing time (18933 ℃ day hrs.). Among the varieties, GJG-31 variety accumulated lowest heliothermal unit (20082 ℃ day hrs.) and GG-34 had accumulated the highest heliothermal unit (21194 ℃ day hrs.). The heliothermal unit also decrease with advancement in dates of sowing. This might be due to reduction of crop period with delay in the date of sowing. These findings are in agreement with Mote and Pandey (2017), Dodiya (2022), Kumar *et al.* (2022), Limbasiya (2022), Yadav *et al.* (2023) and Yadavrao *et al.* (2023).

**3.1.4 Hygrothermal Unit-I (HgTU-I)**

The accumulated morning hygrothermal unit or hygrothermal unit-I required by the crop for various phenophases under different sowing time and varieties is presented in the Table 1. In the sowing time, the hygrothermal unit-I was highest in 4th SMW (151772 ℃ per cent) than other sowing time. The minimum hygrothermal unit-I accumulated in 8th SMW sowing time (145541 ℃ per cent). Among the varieties, GJG-31 variety accumulated lowest hygrothermal unit-I (142443 ℃ per cent) and GG-34 had accumulated the highest hygrothermal unit-I (155612 ℃ per cent). The HgTU-I generally decrease with delay in sowing time but it increased in 10th SMW. It might be due to increased relative humidity-I during later crop stage which was the result of early onset of monsoon. The findings are in close association with Kumar *et al.* (2018) and Limbasiya (2022).

**3.1.5 Hygrothermal Unit-II (HgTU-II)**

The accumulated afternoon hygrothermal unit or hygrothermal unit-II during various crop phenophases under different sowing time and varieties is presented in the Table 1. In the sowing time, the hygrothermal unit-II was highest in 10th SMW (54048 ℃ per cent) than other sowing time. The minimum hygrothermal unit-II accumulated in 6th SMW sowing time (49221 ℃ per cent). Among the varieties, GJG-31 variety accumulated lowest hygrothermal unit-II (48686 ℃ per cent) and GG-34 had accumulated the highest hygrothermal unit-II (55380 ℃ per cent). It might be due to increased relative humidity-II during later crop stage which was the result of early onset of monsoon. The findings are in close association with Kumar *et al.* (2018), Dodiya (2022) and Limbasiya (2022).

**Table 1 Effect of treatments on various agrometeorological indices to reach the monkey maturity in summer groundnut during crop season 2024**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **GDD**  **(℃ day)** | **PTU**  **(℃ day hrs.)** | **HTU**  **(℃ day hrs.)** | **HgTU-I**  **(℃ per cent)** | **HgTU-II**  **(℃ per cent)** |
| **Sowing Time** | | | | | |
| **D1: 4th SMW** | 2230 | 27426 | 21579 | 151772 | 50915 |
| **D2: 6th SMW** | 2215 | 27393 | 21384 | 147312 | 49221 |
| **D3: 8th SMW** | 2209 | 27175 | 20314 | 145541 | 51432 |
| **D4: 10th SMW** | 2101 | 26851 | 18933 | 146638 | 54048 |
| **Varieties** | | | | | |
| **V1: GJG-31** | 2107 | 26226 | 20082 | 142443 | 48686 |
| **V2: GG-34** | 2310 | 28619 | 21194 | 155612 | 55380 |
| **V3: GG-37** | 2149 | 26790 | 20380 | 145393 | 50146 |

**3.2 Heat Use Efficiency (HUE)**

The heat use efficiency attained by different sowing time and varieties is presented in the Table 2. The heat use efficiency was highest in 6th SMW (1.16 kg ha-1 day-1) which was followed by 8th SMW (1.04 kg ha-1 day-1). The lowest heat use efficiency was taken by 4th SMW (0.83 kg ha-1 day-1). Amon the varieties, the highest HUE was obtained by GJG-31 (1.14 kg ha-1 day-1) and it was followed by GG-37 (1.03 kg ha-1 day-1). The lowest HUE was recorded by GG-34 (0.86 kg ha-1 day-1). The similar findings have been reported by Kingra and Kaur (2012), Sudheer (2013), Vora *et al.* (2018), Dodiya (2022) and Limbasiya (2022).

**3.3 Phenothermal Index**

The phenothermal index for different sowing time and varieties is presented in Table 2. The phenothermal index was highest in 10th SMW (19.94 ℃ day hrs./day) which was followed by 8th SMW (19.77 ℃ day hrs./day). The lowest phenothermal index was taken by 4th SMW (17.14 ℃ day hrs./day). Amon the varieties, the highest phenothermal index was obtained by GG-34 (18.85 ℃ day hrs./day) and it was followed by GG-37 (18.04 ℃ day hrs./day). The lowest phenothermal index was recorded by GJG-31 (17.99 ℃ day hrs./day). The findings are in close agreement with Dodiya (2022) and Limbasiya (2022).

**Table 2 Effect of treatments on heat use efficiency and phenothermal index to reach box the maturity in summer groundnut during crop season 2024**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Heat Use Efficiency**  **(kg ha-1 day-1)** | **Phenothermal Index**  **(℃ day hrs./day)** |
| **Sowing Time** | | |
| **D1: 4th SMW** | 0.83 | 17.14 |
| **D2: 6th SMW** | 1.16 | 18.69 |
| **D3: 8th SMW** | 1.04 | 19.77 |
| **D4: 10th SMW** | 1.00 | 19.94 |
| **Varieties** | | |
| **V1: GJG-31** | 1.14 | 17.99 |
| **V2: GG-34** | 0.86 | 18.85 |
| **V3: GG-37** | 1.03 | 18.04 |

**4. CONCLUSION**

From the present study on groundnut during summer season 2024, we concluded that the GDD, HTU and PTU decreased with delay in sowing and it was highest in 4th SMW and lowest in 10th SMW. The HgTU-I decreased with delayed in sowing but it was greater in 10th SMW than 8th SMW and hence it was maximum in 4th SMW but was lowest in 8th SMW and highest HgTU-II was observed in 10th SMW. HUE was found highest in the 6th SMW. Phenothermal index was found maximum in 10th SMW. Among the varieties, GJG-31 variety takes lowest and GG-34 variety takes highest GDD, PTU, HTU, HgTU-I, HgTU-II and Phenothermal Index to reach the maturity respectively. GJG-31 had the highest and GG-34 had lowest HUE respectively.

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