*Original Research Article*

Effect of sowing dates on performance of summer groundnut cultivars

ABSTRACT

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| --- |
| **Aims:** To study the effect of different sowing dates on performance 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 cultivars *viz.,* V1 : GJG-31, V2 : GG-34 and V3 : GG-37. The study assessed plant population, growth parameters: days to 50 per cent flowering, plant height at 60, 90 DAS and at harvest (cm), number of branches per plant at harvest and dry matter accumulation at 30, 60, 90 DAS and at harvest (g/plant) with yield attribute and yield: number of pods per plant, total number of pegs per plant, pod yield (kg/ha), haulm yield (kg/ha), Shelling percentage (%) and seed index (g). Physiological parameters were also recorded as Crop Growth Rate (CGR) (g m-2 day-1) and Relative Growth Rate (RGR) (g g-1 day-1).  **Results:** The results showed that sowing in 6th SMW resulted in significantly higher plant height at 60, 90 DAS and at harvest, number of branches per plant at harvest and dry matter accumulation at 30, 60, 90 DAS and at harvest. The sowing in 6th SMW also resulted in significantly higher number of pods per plant, total number of pegs per plant, pod yield, haulm yield, CGR and RGR. Among the cultivars, GJG-31 was observed the highest in plant height, dry matter accumulation, pods per plant, total number of pegs per plant, seed index, CGR and RGR. The cultivar GJG-31 also produced the highest pod yield as well as haulm yield.  **Conclusion:** Based on this experiment it can be concluded that most suitable sowing dates reported is 6th SMW. GJG-31 cultivar gave superior result as compared to other cultivars. It can be also concluded that the treatment combination D2V1 *viz.,* sowing in 6th SMW with GJG-31 is best suitable for sowing in South Saurashtra Agro-climatic conditions. |

*Keywords: Summer groundnut, sowing dates, cultivars, 6th SMW, GJG-31*

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume crop which belongs to family *Leguminosae* and has its origin in South America. It was introduced by Portuguese from Brazil to West Africa and then to South Western India in the 16th Century (Chandran *et al.,* 2016). It is a major oilseed crop 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). The sowing time plays an important role among various agronomic factors, which influence the yield of groundnut. Fine management of crop by date of sowing is a good approach to enhance both crop yield and economic benefit. Shift in sowing dates directly influence both thermo and photoperiod and consequently a great bearing on the phasic development and partitioning of dry matter (Rani *et al*., 2012). For summer groundnut, germination is affected due to low temperature if sowing is done early and if crop is sown late, there are chances of damage from rain at maturity. It is therefore, necessary to find out optimum time of sowing for groundnut in summer season for obtaining higher productivity. The optimum time of sowing ensures the harmony between the vegetative and reproductive phases on one hand and the climatic rhythm on the other hand helps in realizing the potential yield. Sometime farmers faced problems regarding early monsoon at the time of harvesting, So, timely sowing is necessary for particular cultivar in case of summer season. Keeping this in mind, the research topic is taken “Effect of sowing dates on performance of summer groundnut cultivars”. This research paper will provide valuable insights into the interaction between sowing time and cultivar selection, contributing to the development of effective strategies for maximizing productivity and meeting the increasing global demand for this vital crop.

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 cultivars as vertical plot treatments with three replications. The treatments consisted of four sowing dates : D1 : 4th SMW (Standard Meteorological Week) , D2 : 6th SMW, D3 : 8th SMW and D4 : 10th SMW and three cultivars: 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 seeds 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 cultivars 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. The plant population at 20 DAS (Days After Sowing) and at harvest was counted. Growth and yield attributing characters *viz.,* days to 50 per cent flowering, plant height at 60, 90 DAS and at harvest (cm), number of branches per plant at harvest and dry matter accumulation at 30, 60, 90 DAS and at harvest (g/plant), number of pods per plant, total number of pegs per plant, Shelling percentage (%) and seed index (g) were recorded. The pod yield (kg/ha) and haulm yield (kg/ha) were recorded at harvesting of the crop. Physiological parameters *viz.,* Crop Growth Rate (CGR) ((g m-2 day-1) and Relative Growth Rate (RGR) (g g-1 day-1) were also calculated by using the following formula:

Crop Growth Rate (CGR) =

Relative Growth Rate (RGR) =

where, W1= Dry weight in grams at time t1

W2= Dry weight in grams at time t2

t2-t1= Time interval (days)

A= Land area (m2)

3. results and discussion

**3.1 Effect of sowing dates and cultivars**

**3.1.1 Plant population**

The data presented in Table 1 revealed that sowing dates and vars did not exert significant effect on initial and final plant population in summer groundnut.

**3.1.2 Growth parameters**

***3.1.2.1* Days to 50 per cent flowering**

The data presented in Table 1 revealed that sowing dates and cultivars had non-significant effect on days to 50 per cent flowering.

***3.1.2.2* Plant height at 60, 90 DAS and harvest (cm)**

The results shown in Table 1 revealed that the plant height at maturity was significantly influenced by sowing dates and cultivars. The significant maximum plant height at 60 DAS (20.27 cm), at 90 DAS (22.42 cm) and at harvest (23.44 cm) was observed in the 6th SMW, which was at par with 8th SMW for 90 DAS (20.55 cm) and at harvest (21.81 cm). Among the cultivars, the significant maximum plant height at 60 DAS (19.35 cm), at 90 DAS (21.99 cm) and at harvest (23.42 cm) was obtained by GJG-31 cultivar, which was at par with GG-37 at 60 DAS (17.86 cm). The result was may be due to favourable environmental conditions, including optimal temperature, sunlight and soil moisture during 6th SMW, which promoted vigorous growth. In contrast, sowing during 4th SMW had encountered relatively lower temperatures and shorter day length, which suppressed vegetative growth and late sowing during 8th and 10th SMW had exposed plant to terminal heat stress and accelerated phenological development, leading to restricted plant height. The finding was similar with Vijayakumar and Geethalakshmi (2018), Birajdar *et al.* (2020), Sireesha and Dawson *et al.* (2022) and Patoliya *et al.* (2024).

***3.1.2.3* Number of branches per plant at harvest**

The data represented in Table 1 showed that sowing dates have significant effect on number of branches per plant at harvest. The significant number of branches per plant at harvest (9.22) was observed in 6th SMW and was followed by 8th SMW (8.11) and 10th SMW (7.78). Among the cultivars, the result was found to be non-significant. It might be due to timely sowing during 6th SMW had experience favourable vegetative phase, allowing the crop sufficient time for development of productive branches. Delayed sowing shortened the vegetative phase, resulting in fewer branches due to early transition to reproductive phase. The results are in accordance with the findings of Chaudhari *et al.* (2018), Shendage *et al.* (2018), Birajdar *et al.* (2020) and Reager *et al.* (2024).

***3.1.2.4* Dry matter accumulation at 30, 60, 90 DAS and at harvest (g)**

According to Table 1 dry matter accumulation at 30, 60, 90 DAS and at harvest was significantly influenced by sowing dates. The significant maximum dry matter accumulation at 30 DAS (7.24 g), at 60 DAS (18.38 g), at 90 DAS (27.59 g) and at harvest (32.84 g) was found under 6th SMW, which was at par with 8th SMW in case of 30 DAS (7.21 g), 60 DAS (16.83 g) and 90 DAS (26.38 g). Among the cultivars, significant maximum dry matter accumulation at 30 DAS (6.58 g), at 60 DAS (17.01 g), at 90 DAS (26.77 g) and at harvest (31.82 g) was obtained by GJG-31 cultivar, which was at par with GG-37 at 30 DAS (6.25 g), 60 DAS (16.29 g), 90 DAS (25.56 g) and at harvest (30.51 g). It could be due to environmental conditions during 6th SMW might have promoted photosynthetic activity, better root development and improved nutrient uptake, which might have led to higher biomass production, while reduced dry matter accumulation during early and late sowing might be because of sub-optimal temperature and lower growth vigour and reduced growing duration and stress condition respectively which might restrict photosynthate accumulation. The similar results have been reported by Shendage *et al.* (2018), Vijaykumar and Geethalakshmi (2018), Birajdar *et al.* (2020), Sireesha and Dawson *et al.* (2022), Nayak *et al.* (2023) and Patoliya *et al.* (2024).

**3.1.3 Yield attributes and yield**

***3.1.3.1* Number of pods per plant**

The results showed in Table 2 revealed that sowing dates significantly influenced the number of pods per plant. The significantly highest number of pods per plant (16.40) was recorded in 6th SMW) and was followed by 8th SMW (14.95) and 10th SMW (13.38). Among the cultivars, GJG-31 recorded the significantly highest number of pods per plant (15.54), which was followed by GG-37 (14.26). This might be due to sowing in 6th SMW provided optimal soil moisture, suitable temperatures and optimum sunshine during the critical phases reproductive phase. During early sowing, lower temperature might have adversely affected floral initiation and phase. During delayed sowing, the terminal heat might have led to poor pod filling. The findings are in close agreement with those obtained by Kumar *et al.* (2017), Chaudhari *et al.* (2018), Shendage *et al.* (2018), Birajdar *et al.* (2020), Nayak *et al.* (2023), Patoliya *et al.* (2024) and Reager *et al.* (2024).

***3.1.3.2* Total number of pegs per plant**

According to Table 2, the total number of pegs per plant was significantly influenced by sowing dates and cultivars. The significant maximum number of pegs (17.91) was observed in 6th SMW, which remain statistically at par with 8th SMW (16.83). Among the cultivars, the significantly maximum total number of pegs per plant (17.07) was observed in GJG-31, which was statistically at par with GG-37 (16.28). Peg development is maximized when flowering and peg elongation coincide with moderate temperature and adequate moisture as it promotes better vegetative growth, enhanced flowering and efficient peg initiation. These conditions might have served during 6th SMW sowing. Lower night temperatures during early sowing reduced enzymatic activity and slower the physiological process which might result in the delay flowering and poor peg penetration while during late sowing higher temperature might have cause flower drop and peg abortion. The results are in close association with findings of Birajdar *et al.* (2020) and Reager *et al.* (2024).

***3.1.3.3* Shelling percentage (%)**

The results showed in Table 2 revealed that sowing dates and cultivars had non-significant effect on shelling percentage.

***3.1.3.4* Seed index (g)**

The data presented in Table 2 showed that sowing dates had non-significant effect and cultivars had significant effect on test weight. Among the cultivars, the significantly higher test weight (38.90 g) was found in GJG-31, which was followed by GG-37 (36.09 g). The finding was similar with Meena *et al.* (2015) and Patoliya *et al.* (2024).

***3.1.3.5* Pod yield (kg/ha)**

The data represented in the Table 2 showed that time of sowing and varieties have significant effect on pod yield. The significantly higher pod yield (2563 kg/ha) was found under 6th SMW, which was followed by 8th SMW (2298 kg/ha) and 10th SMW (2108 kg/ha). Among the varieties, the significantly higher pod yield (2403 kg/ha) was observed in the GJG-31, which was followed by GG-37 (2209 kg/ha).

**Table 1 Effect of sowing dates on plant population and growth parameters in summer groundnut cultivars**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Initial plant population/ ha** | **Final plant population/ ha** | **Days to 50% flowering** | **Plant height (cm)** | | | **Number of branches/plant** | **Dry matter accumulation (g/plant)** | | | |
| **60 DAS** | **90 DAS** | **At harvest** | **30 DAS** | **60 DAS** | **90 DAS** | **At harvest** |
| **Sowing date** | | | | | | | | | | | |
| **D1: 4th SMW** | 142716 | 138910 | 45.89 | 15.26 | 18.08 | 19.48 | 7.00 | 4.56 | 14.62 | 22.90 | 29.37 |  |
| **D2: 6th SMW** | 144527 | 141393 | 42.67 | 20.27 | 22.42 | 23.44 | 9.22 | 7.24 | 18.38 | 27.59 | 32.84 |
| **D3: 8th SMW** | 145432 | 142060 | 41.22 | 17.98 | 20.55 | 21.81 | 8.11 | 7.21 | 16.83 | 26.38 | 30.74 |
| **D4: 10th SMW** | 141033 | 137438 | 40.67 | 17.66 | 19.25 | 20.71 | 7.78 | 5.68 | 14.87 | 24.97 | 28.41 |
| S.Em.± | 1978.07 | 2133.67 | 1.09 | 0.64 | 0.60 | 0.55 | 0.31 | 0.19 | 0.47 | 0.60 | 0.55 |
| C.D. at 5 % | NS | NS | NS | 2.21 | 2.07 | 1.91 | 1.08 | 0.65 | 1.64 | 2.06 | 1.91 |
| C.V. % | 4.14 | 4.57 | 7.65 | 10.76 | 8.96 | 7.73 | 11.68 | 9.08 | 8.78 | 7.03 | 5.44 |
| **Cultivars** | | | | | | | | | | | |
| **V1: GJG-31** | 144074 | 140882 | 41.75 | 19.35 | 21.99 | 23.42 | 8.00 | 6.58 | 17.01 | 26.77 | 31.82 |
| **V2: GG-34** | 142966 | 139520 | 44.00 | 16.17 | 18.86 | 20.03 | 8.58 | 5.69 | 15.22 | 24.05 | 28.69 |
| **V3: GG-37** | 143241 | 139449 | 42.08 | 17.86 | 19.37 | 20.63 | 7.50 | 6.25 | 16.29 | 25.56 | 30.51 |
| S.Em.± | 1673.36 | 1765.40 | 0.92 | 0.50 | 0.51 | 0.40 | 0.24 | 0.16 | 0.33 | 0.45 | 0.47 |
| C.D. at 5 % | NS | NS | NS | 1.98 | 1.99 | 1.57 | NS | 0.62 | 1.30 | 1.77 | 1.86 |
| C.V. % | 4.04 | 4.37 | 7.51 | 9.82 | 8.73 | 6.48 | 10.38 | 8.92 | 7.11 | 6.14 | 5.40 |
| **Interaction (D x V)** | | | | | | | | | | | |
| S.Em.± | 2606.72 | 2846.15 | 1.14 | 0.88 | 0.81 | 0.74 | 0.45 | 0.32 | 0.56 | 0.83 | 0.87 |
| C.D. at 5 % | NS | NS | NS | NS | NS | NS | NS | 0.97 | 1.73 | 2.55 | 2.67 |
| C.V.% | 3.15 | 3.52 | 4.63 | 8.57 | 6.98 | 5.99 | 9.66 | 8.84 | 6.03 | 5.64 | 4.95 |

This could be due to meteorological condition during 6th SMW may have increased flower production, higher peg penetration and better pod development which directly contribute to enhanced pod yield. In contrast, meteorological condition during early sowing may have reduce vigor, rate of photosynthesis and dry matter accumulation resulting in fewer pods per plant while, meteorological condition during late sowing may have resulted in flower drop, poor peg formation and incomplete pod filling. The results are in accordance with Banik *et al.* (2009), Kumar *et al.* (2017), Chaudhari *et al.* (2018), Shendage *et al.* (2018), Vijaykumar and Geethalakshmi (2018), Kaur *et al.* (2020) and Sai *et al.* (2022).

***3.1.3.6* Haulm yield (kg/ha)**

The data furnished in the Table 2 showed that sowing dates have significant effect on haulm yield. The significantly higher haulm yield (2882 kg/ha) was found under 6th SMW, which was at par with 8th SMW (2265 kg/ha) and 10th SMW (2771 kg/ha). Among the cultivars, the significantly higher haulm yield (2840 kg/ha) was observed in the GJG-31, which was followed by GG-37 (2686 kg/ha).It might be due to 6th SMW sowing provided favourable weather conditions which promoted canopy development, photosynthetic activity, leaf area development and strong stem growth, resulting in higher accumulation of haulm biomass. In contrast, weather conditions during other sowing dates might have negative effect on vegetative growth which lead leads to limited accumulation of haulm biomass. These findings are in agreement with those reported by Kumar *et al.* (2017), Pal *et al.* (2018), Vijayakumar and Geethalakshmi (2018), Sireesha and Dawson (2022) and Nayak *et al.* (2023).

**3.1.4 Physiological parameters**

***3.1.4.1* Crop Growth Rate at 0-30, 30-60, 60-90 and 90 DAS-harvest (g m-2 day-1)**

According to the data showed in Table 3 the sowing dates and cultivars had significant effect on crop growth rate. The significantly maximum crop growth rate at 0-30 DAS (3.58 g m-2 day-1), at 30-60 DAS (14.80 g m-2 day-1), at 60-90 DAS (18.51 g m-2 day-1) and at 90 DAS-harvest (19.34 g m-2 day-1) was observed in 6th SMW, which was statistically at par with 8th SMW in case of 0-30 DAS (3.56 g m-2 day-1), 30-60 DAS(13.27 g m-2 day-1) and 60-90 DAS (18.07 g m-2 day-1). Among the cultivars, the significantly maximum crop growth rate at 0-30 DAS (3.25 g m-2 day-1), at 30-60 DAS (13.76 g m-2 day-1), at 60-90 DAS (18.23 g m-2 day-1) and at 90 DAS-harvest (18.34 g m-2 day-1) was observed in GJG-31, which was statistically at par with GG-37 at 0-30 DAS (3.09 g m-2 day-1), 30-60 DAS(13.20 g m-2 day-1), 60-90 DAS (17.44 g m-2 day-1) and 90 DAS-harvest (17.72 g m-2 day-1). This might be the result of enhanced leaf area expansion, canopy development and photosynthetic assimilation which supported increased dry matter production and resulted in higher CGR under 6th SMW sowing. In contrast, during early sowing, sub-optimal conditions might have reduced enzyme activity and nutrient uptake and during delayed sowing increased air temperature might have accelerated senescence and reduce the effective duration of photosynthesis. Under both conditions there could be decline in biomass accumulation and at end decline in CGR. The results are in close association with findings of Meena and Yadav (2014), Chongdar *et al.* (2015), Reager *et al.* (2020), Sireesha and Dawson (2022) and Nayak *et al.* (2023).

**Table 2 Effect of sowing dates on yield attributes and yield in summer groundnut cultivars**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Number of pods/plant** | **Total number of pegs/plant** | **Shelling**  **(%)** | **Test weight**  **(g)** | **Pod yield (kg/ha)** | **Haulm yield (kg/ha)** |
| **Sowing date** | | | | | | |
| **D1: 4th SMW** | 12.36 | 14.63 | 66.10 | 36.22 | 1849 | 2223 |
| **D2: 6th SMW** | 16.40 | 17.91 | 69.50 | 37.71 | 2563 | 2882 |
| **D3: 8th SMW** | 14.95 | 16.83 | 69.01 | 36.68 | 2298 | 2797 |
| **D4: 10th SMW** | 13.38 | 15.77 | 67.83 | 35.86 | 2108 | 2771 |
| S.Em.± | 0.39 | 0.43 | 1.43 | 0.86 | 57.35 | 90.44 |
| C.D. at 5 % | 1.34 | 1.50 | NS | NS | 198.45 | 312.98 |
| C.V. % | 8.14 | 7.96 | 6.32 | 7.04 | 7.80 | 10.17 |
| **Cultivars** | | | | | | |
| **V1: GJG-31** | 15.54 | 17.07 | 66.37 | 38.90 | 2403 | 2840 |
| **V2: GG-34** | 13.01 | 15.51 | 68.01 | 34.73 | 2001 | 2479 |
| **V3: GG-37** | 14.26 | 16.28 | 69.95 | 36.09 | 2209 | 2686 |
| S.Em.± | 0.31 | 0.29 | 1.11 | 0.69 | 45.10 | 61.55 |
| C.D. at 5 % | 1.23 | 1.16 | NS | 2.71 | 177.10 | 241.69 |
| C.V. % | 7.63 | 6.27 | 5.65 | 6.53 | 7.09 | 7.99 |
| **Interaction (D x V)** | | | | | | |
| S.Em.± | 0.62 | 0.57 | 1.78 | 1.28 | 77.88 | 93.51 |
| C.D. at 5 % | NS | NS | NS | NS | 239.98 | 288.14 |
| C.V.% | 7.53 | 6.03 | 4.53 | 6.08 | 6.12 | 6.07 |

***3.1.4.2* Relative Growth Rate at 30-60, 60-90 and 90 DAS-harvest (g g-1 day-1)**

The data furnished in Table 3 showed that the sowing dates and cultivars had significant effect on relative growth rate. The significantly maximum relative growth rate at 30-60 DAS (2.84 g g-1 day-1), at 60-90 DAS (3.22 g g-1 day-1) and at 90 DAS-harvest (3.38 g g-1 day-1) was observed in 6th SMW. Among the cultivars, the significantly maximum relative growth rate at 30-60 DAS (2.76 g g-1 day-1), at 60-90 DAS (3.18 g g-1 day-1) and at 90 DAS-harvest (3.34 g g-1 day-1) was observed in GJG-31. This could be because of probable more effective leaf area expansion and photosynthetic activity during 6th SMW which might have enhance metabolic efficiency, resulting in higher RGR due to improved assimilates production and utilization. The lower RGR in other sowing dates might because of in early sowing time sub-optimal environmental conditions might have reduced metabolic activity and in delayed sowing date, terminal heat and moisture stress might have led to decrease in assimilated production and higher respiratory losses. The findings are in close accordance with Meena and Yadav (2014), Reager *et al.* (2020), Sireesha and Dawson (2022) and Nayak *et al.* (2023).

**3.2 Interaction effect**

**3.2.1 Plant population**

The interaction effect between sowing dates and cultivars on initial and final plant population was found non-significant.

**3.2.2 Growth parameters**

Among all growth parameters, the interaction effect between sowing dates and cultivars on only dry matter accumulation was found significant. The data represented in Table 4 to 7 revealed that the treatment combination D3V1 (8th SMW and GJG-31) recorded significantly maximum dry matter accumulation at 30 DAS (8.70 g), while treatment combination D2V3 (6th SMW and GG-37) recorded significantly maximum dry matter at 60 DAS (19.29 g) and treatment combination D2V1 (6th SMW and GJG-31) recorded significantly maximum dry matter accumulation at 90 DAS (30.30 g) and at harvest (35.87 g).

**3.2.3 Yield attributes and yield**

The interaction effect between sowing dates and cultivars on pod yield and haulm yield were found to be significant. The data represented in Table 8 showed that the treatment combination D2V1 (6th SMW and GJG-31) registered the significantly highest pod yield (2410 kg/ha). The data represented in Table 9 showed that the treatment combination D2V1 (6th SMW and GJG-31) registered the significantly highest pod yield (3074 kg/ha). No significant interactions were observed between sowing dates and cultivars in all other yield attribute and yield parameters.

**Table 3 Effect of sowing dates on physiological parameters in summer groundnut cultivars**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Crop Growth Rate (CGR) (g m-2 day-1)** | | | | **Relative Growth Rate (RGR) (g g-1 day-1)** | | |
| **0-30 DAS** | **30-60 DAS** | **60-90 DAS** | **90 DAS-harvest** | **30-60 DAS** | **60-90 DAS** | **90 DAS-harvest** |
| **Sowing date** | | | | | | | |
| **D1: 4th SMW** | 2.25 | 12.37 | 14.98 | 17.58 | 2.63 | 3.01 | 3.25 |
| **D2: 6th SMW** | 3.58 | 14.80 | 18.51 | 19.34 | 2.84 | 3.22 | 3.38 |
| **D3: 8th SMW** | 3.56 | 13.27 | 18.07 | 17.45 | 2.75 | 3.17 | 3.31 |
| **D4: 10th SMW** | 2.80 | 12.06 | 17.96 | 16.11 | 2.64 | 3.14 | 3.24 |
| S.Em.± | 0.09 | 0.46 | 0.58 | 0.39 | 0.03 | 0.03 | 0.02 |
| C.D. at 5 % | 0.32 | 1.59 | 1.99 | 1.34 | 0.10 | 0.10 | 0.08 |
| C.V. % | 9.08 | 10.51 | 9.62 | 6.61 | 3.21 | 2.66 | 2.19 |
| **Cultivars** | | | | | | | |
| **V1: GJG-31** | 3.25 | 13.76 | 18.23 | 18.34 | 2.76 | 3.18 | 3.34 |
| **V2: GG-34** | 2.81 | 12.41 | 16.47 | 16.80 | 2.66 | 3.08 | 3.25 |
| **V3: GG-37** | 3.09 | 13.20 | 17.44 | 17.72 | 2.72 | 3.14 | 3.30 |
| S.Em.± | 0.08 | 0.26 | 0.33 | 0.23 | 0.02 | 0.02 | 0.01 |
| C.D. at 5 % | 0.31 | 1.01 | 1.30 | 0.89 | 0.07 | 0.06 | 0.05 |
| C.V. % | 8.92 | 6.81 | 6.61 | 4.48 | 2.36 | 1.75 | 1.40 |
| **Interaction (D x V)** | | | | |  |  |  |
| S.Em.± | 0.16 | 0.36 | 0.65 | 0.43 | 0.03 | 0.03 | 0.03 |
| C.D. at 5 % | 0.48 | 1.10 | 2.00 | 1.33 | NS | 0.10 | 0.08 |
| C.V. % | 8.84 | 4.72 | 6.46 | 4.25 | 2.20 | 1.83 | 1.42 |

**Table 4 Interaction effect of sowing dates and groundnut cultivars on dry matter boex accumulation (g/plant) at 30 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 4.00 | 4.33 | 5.33 | 4.55 |
| **D2** | 7.00 | 6.80 | 7.93 | 7.23 |
| **D3** | 8.70 | 6.73 | 6.20 | 7.21 |
| **D4** | 6.60 | 4.90 | 5.53 | 5.68 |
| **Mean** | 6.57 | 5.69 | 6.25 | - |
| S.Em.± | 0.32 | | | |
| C.D. at 5 % | 0.97 | | | |
| C.V. % | 8.84 | | | |

**Table 5 Interaction effect of sowing dates and groundnut cultivars on dry matter boxers accumulation (g/plant) at 60 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 14.34 | 13.93 | 15.54 | 14.61 |
| **D2** | 18.68 | 17.17 | 19.29 | 18.38 |
| **D3** | 19.05 | 15.79 | 15.67 | 16.84 |
| **D4** | 15.97 | 13.97 | 14.66 | 14.87 |
| **Mean** | 17.01 | 15.22 | 16.29 | - |
| S.Em.± | 0.56 | | | |
| C.D. at 5 % | 1.73 | | | |
| C.V. % | 6.03 | | | |

**Table 6 Interaction effect of sowing dates and groundnut cultivars on dry matter monkey accumulation (g/plant) at 90 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 22.15 | 21.40 | 25.16 | 22.90 |
| **D2** | 30.30 | 25.99 | 26.47 | 27.59 |
| **D3** | 28.67 | 24.93 | 25.53 | 26.38 |
| **D4** | 25.97 | 23.87 | 25.07 | 24.97 |
| **Mean** | 26.77 | 24.05 | 25.56 | - |
| S.Em.± | 0.83 | | | |
| C.D. at 5 % | 2.55 | | | |
| C.V. % | 5.64 | | | |

**Table 7 Interaction effect of sowing dates and groundnut cultivars on dry matter monkey accumulation (g/plant) at harvest**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 29.02 | 27.47 | 31.62 | 29.37 |
| **D2** | 35.87 | 30.79 | 31.87 | 32.84 |
| **D3** | 33.07 | 29.07 | 30.10 | 30.74 |
| **D4** | 29.33 | 27.43 | 28.47 | 28.41 |
| **Mean** | 31.82 | 28.69 | 30.51 | - |
| S.Em.± | 0.84 | | | |
| C.D. at 5 % | 2.60 | | | |
| C.V. % | 4.81 | | | |

**Table 8 Interaction effect of sowing dates and groundnut cultivars on pod yield (kg/ha)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 2159 | 1682 | 1707 | 1849.33 |
| **D2** | 2693 | 2430 | 2565 | 2562.67 |
| **D3** | 2552 | 2110 | 2232 | 2298.00 |
| **D4** | 2206 | 1785 | 2333 | 2108.00 |
| **Mean** | 2402.50 | 2001.75 | 2209.25 | - |
| S.Em.± | 77.88 | | | |
| C.D. at 5 % | 239.98 | | | |
| C.V. % | 6.12 | | | |

**Table 9 Interaction effect of sowing dates and groundnut cultivars on haulm yield (kg/ha)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 2553 | 1937 | 2178 | 2222.89 |
| **D2** | 3074 | 2783 | 2789 | 2882.33 |
| **D3** | 2938 | 2701 | 2751 | 2797.44 |
| **D4** | 2795 | 2494 | 3023 | 2770.67 |
| **Mean** | 2840.17 | 2478.92 | 2685.92 | - |
| S.Em.± | 93.51 | | | |
| C.D. at 5 % | 288.14 | | | |
| C.V. % | 6.07 | | | |

**3.2.4 Physiological parameters**

The interaction effect between sowing dates and cultivars on CGR and RGR were found to be significant. The data given in Table 10 to Table 13 revealed that the treatment combination D3V1 (8th SMW and GJG-31) recorded significantly higher crop growth rate at 0-30 DAS (4.30 g m-2 day-1), while treatment combination D2V1 (6th SMW and GJG-31) recorded significantly higher crop growth rate at 30-60 DAS (15.21 g m-2 day-1), at 60-90 DAS (21.08 g m-2 day-1) and at 90 DAS-harvest (20.94 g m-2 day-1). The data given in Table 14 and Table 15 revealed that the treatment combination D2V1 (6th SMW and GJG-31) recorded significantly higher relative growth rate at 60-90 DAS (3.31 g g-1 day-1) and at 90 DAS-harvest (3.47 g g-1 day-1).

**Table 10 Interaction effect of sowing dates and groundnut cultivars on Crop Growth boxes Rate (CGR) (g m-2 day-1) at 0-30 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 1.98 | 2.14 | 2.63 | 2.25 |
| **D2** | 3.46 | 3.36 | 3.92 | 3.58 |
| **D3** | 4.30 | 3.33 | 3.06 | 3.56 |
| **D4** | 3.26 | 2.42 | 2.73 | 2.80 |
| **Mean** | 3.25 | 2.81 | 3.09 | - |
| S.Em.± | 0.16 | | | |
| C.D. at 5 % | 0.48 | | | |
| C.V. % | 8.84 | | | |

**Table 11 Interaction effect of sowing dates and groundnut cultivars on Crop Growth boxes Rate (CGR) (g m-2 day-1) at 30-60 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 12.37 | 11.83 | 12.91 | 12.37 |
| **D2** | 15.21 | 13.82 | 15.37 | 14.80 |
| **D3** | 14.77 | 12.44 | 12.60 | 13.27 |
| **D4** | 12.71 | 11.55 | 11.93 | 12.06 |
| **Mean** | 13.76 | 12.41 | 13.20 | - |
| S.Em.± | 0.36 | | | |
| C.D. at 5 % | 1.10 | | | |
| C.V. % | 4.72 | | | |

**Table 12 Interaction effect of sowing dates and groundnut cultivars on Crop Growth boxes Rate (CGR) (g m-2 day-1) at 60-90 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 14.17 | 13.90 | 16.86 | 14.98 |
| **D2** | 21.08 | 17.51 | 16.94 | 18.51 |
| **D3** | 19.25 | 17.15 | 17.80 | 18.07 |
| **D4** | 18.42 | 17.30 | 18.16 | 17.96 |
| **Mean** | 18.23 | 16.47 | 17.44 | - |
| S.Em.± | 0.65 | | | |
| C.D. at 5 % | 2.00 | | | |
| C.V. % | 6.46 | | | |

**Table 13 Interaction effect of sowing dates and groundnut cultivars on Crop Growth boxes Rate (CGR) (g m-2 day-1) at 90 DAS-harvest**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 17.20 | 16.83 | 18.72 | 17.58 |
| **D2** | 20.94 | 18.09 | 19.00 | 19.34 |
| **D3** | 18.61 | 16.72 | 17.02 | 17.45 |
| **D4** | 16.61 | 15.55 | 16.16 | 16.11 |
| **Mean** | 18.34 | 16.80 | 17.72 | - |
| S.Em.± | 0.43 | | | |
| C.D. at 5 % | 1.33 | | | |
| C.V. % | 4.25 | | | |

**Table 14 Interaction effect of sowing dates and cultivars on Relative Growth Rate (RGR) box (g g-1 day-1) at 60-90 DAS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 2.98 | 2.95 | 3.10 | 3.01 |
| **D2** | 3.31 | 3.16 | 3.18 | 3.22 |
| **D3** | 3.26 | 3.12 | 3.15 | 3.17 |
| **D4** | 3.18 | 3.10 | 3.14 | 3.14 |
| **Mean** | 3.18 | 3.08 | 3.14 | - |
| S.Em.± | 0.03 | | | |
| C.D. at 5 % | 0.10 | | | |
| C.V. % | 1.83 | | | |

**Table 15 Interaction effect of sowing dates and cultivars on Relative Growth Rate (RGR) box (g g-1 day-1) at 90 DAS-harvest**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sowing dates** | **Cultivars** | | | |
| **V1** | **V2** | **V3** | **Mean** |
| **D1** | 3.22 | 3.20 | 3.32 | 3.25 |
| **D2** | 3.47 | 3.32 | 3.36 | 3.38 |
| **D3** | 3.38 | 3.26 | 3.28 | 3.31 |
| **D4** | 3.28 | 3.21 | 3.25 | 3.24 |
| **Mean** | 3.34 | 3.25 | 3.30 | - |
| S.Em.± | 0.03 | | | |
| C.D. at 5 % | 0.08 | | | |
| C.V. % | 1.42 | | | |

4. Conclusion

Based on this experiment it could be concluded that under the south Saurashtra agro-climatic condition of Junagadh (Gujarat), summer groundnut crop sown in 6th SMW recorded higher yield as compared to other sowing dates. Meteorologically, most suitable environment for cultivation of summer groundnut was reported in 6th SMW. Sowing before and after 6th SMW gradually decreased the seed yield. Gujarat Junagadh Groundnut-31 gave the highest yield as compared to other cultivars (GG-34 and GG-37). On the basis of this experiment, it could be also concluded that the treatment combination D2V1 *viz.,* sowing in 6th SMW with GJG-31 is best suitable for sowing in South Saurashtra Agro-climatic conditions.

Disclaimer (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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