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# Effect of Varieties and Sowing Dates on Growth, Dry Matter Partitioning, Yield and Economics of Groundnut (*Arachis hypogaea* L.)

PALUCHANI MEGHANA REDDY[1], M. N. THIMMEGOWDA[2], M. H. MANJUNATHA[3], MUDALAGIRIYAPPA[4], M. B. RAJEGOWDA[5], R. JAYARAMAIAH[6]

[1]Department of Agronomy, [5&6]Department of Agrometeorology, College of Agriculture, [2&3]All India Coordinated Research Project on Agrometeorology, [4]All India Coordinated Research Project for Dryland Agriculture, UAS, GKVK, Bengaluru - 560 065,

e-Mail : meghana4141@gmail.com

**AUTHORS CONTRIBUTION**

PALUCHANI MEGHANA REDDY : Investigation, data analysis and interpretation, orginal draft prepration

M. N. THIMMEGOWDA : Conceptualization, supervision, interpretation, final validation and editing

M. H. MANJUNATHA ; MUDALAGIRIYAPPA ; M. B. RAJEGOWDA AND R. JAYARAMAIAH : Guidance and draft correction

***Corresponding Author :***
PALUCHANI MEGHANA REDDY

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## ABSTRACT

Groundnut (*Arachis hypogaea* L.) productivity in rainfed ecosystems is strongly influenced by genotype selection and sowing time, as both factors directly determine crop growth dynamics, dry matter accumulation and resource-use efficiency. A field experiment was conducted during *kharif* 2023 and 2024 at the AICRP on Agrometeorology, ZARS, UAS, Bangalore, to evaluate the performance of three groundnut varieties (KCG-6, K-1812 and K-6) sown at two dates (June 2$^{nd}$ fortnight and July 1$^{st}$ fortnight) under a factorial RCBD design. Significant variation was observed among varieties and sowing dates for pod yield, haulm yield, harvest index, dry matter accumulation, leaf area and economic returns. The variety K-1812 consistently produced the highest pod yield (3603 kg ha$^{-1}$), haulm yield (9489 kg ha$^{-1}$), total dry matter and water use efficiency (6.61 kg ha-mm$^{-1}$), outperforming KCG-6 and K-6. Sowing in the July 1$^{st}$ fortnight recorded higher pod yield (2799 kg ha$^{-1}$) and harvest index (0.28), whereas June 2$^{nd}$ fortnight sowing produced greater dry matter and leaf area at all growth stages. Interaction effects were mostly non-significant, except for haulm yield, SPAD at 50% flowering and selected dry matter stages. Economic analysis revealed that K-1812 combined with July 1$^{st}$ fortnight sowing achieved the highest net returns (Rs.108,124 ha$^{-1}$) and B:C ratio (2.65). The study concludes that K-1812 sown in the July 1$^{st}$ fortnight is the most productive and economically rewarding option for rainfed groundnut cultivation in the Eastern Dry Zone of Karnataka.

*Keywords* : Groundnut, Sowing dates, Dry matter partitioning, Leaf area, Water use efficiency, Pod yield, Haulm yield, Rainfed cultivation, Economics

Groundnut (*Arachis hypogaea* L.) is an important oilseed and food legume widely cultivated in tropical and subtropical regions. In India, it plays a critical role in sustaining rural livelihoods, contributing substantially to edible oil supply, fodder availability and farm income. However, the productivity of groundnut remains highly variable under rainfed conditions due to the combined influence of soil type, rainfall variability, genotype adaptability and agronomic management. Among these factors, the choice of an appropriate variety and optimum sowing time are particularly crucial because they determine the crop's exposure to temperature, rainfall distribution, solar radiation and soil moisture during key phenological stages.

Varietal performance in groundnut varies considerably across agro-ecological zones due to differences in growth habit, duration, dry matter partitioning and physiological responses. Genotypes also differ in their ability to utilize available resources efficiently and to convert accumulated biomass into economic yield. Understanding these genotype-specific responses is essential for tailoring agronomic practices that improve yield stability under rainfed production systems.

Similarly, sowing time is a major non-monetary input that influences germination, canopy development, flowering, pod formation and final yield. Early or delayed sowing can result in exposure to suboptimal temperature or moisture stress, thereby reducing physiological efficiency and dry matter accumulation. In regions with highly variable monsoon onset, identifying an appropriate sowing window is vital for maximizing yield and resource-use efficiency.

The present study was undertaken to evaluate the influence of three groundnut varieties and two sowing dates on growth parameters, dry matter partitioning, yield attributes, pod and haulm yield, water use efficiency and economic viability during *kharif* 2023 and 2024 at GKVK Bengaluru.

## Material and Methods

### Experimental Site

The experiment was conducted at AICRP on Agro-meteorology field unit, Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, Gandhi Krishi Vignana Kendra (GKVK), Bengaluru, during *kharif* 2023 and 2024 under rainfed condition. The experimental unit was located at geographical coordinates of 13° 05' North latitude and 77° 34' East longitude with an altitude of 924 meters above the mean sea level, which comes under Eastern Dry Zone, Karnataka.

### Soil and its Characteristics

The soil of the experimental site was sandy clay loam in texture with 36.10% coarse sand, 28.60% fine sand, 6.50% silt, and 28.80% clay. The soil was slightly acidic (pH 5.80) with low EC (0.30 dS $m^{-1}$), medium organic carbon (0.45%), available nitrogen (251.4 kg $ha^{-1}$) and phosphorus (29.3 kg $ha^{-1}$) and low available potassium (120.8 kg $ha^{-1}$).

### Climatic Conditions

Monthly mean meteorological data recorded at the nearby observatory at AICRP on Agrometeorology unit, Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, GKVK, Bengaluru for the crop growth period during 2023 and 2024 was collected. The normal and actual of weather parameters *viz.*, rainfall, mean temperature (maximum and minimum), relative humidity, wind speed and bright sunshine hours are presented in Fig.1.

### Experimental Details

The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial concept and the six treatments were replicated for four times.

### Treatment Details

The experiment consisted 2 factors, as detailed below.

| Factor A : Varieties (V) | Factor B: Dates of sowing (D) |
|---|---|
| $V_1$ : KCG - 6 | $D_1$: June 2 nd FN |
| $V_2$ : K - 1812 (Kadiri Lepakshi) | $D_2$: July 1 st FN |
| $V_3$ : K - 6 | |

## Results and Discussion

### Effect of Varieties and Sowing Dates on Growth, Dry Mater Partitioning and Yield in Groundnut

*Effect of Varieties on Growth, Dry Matter Partitioning and Yield* : Improved crop varieties generally play a major role in enhancing productivity. However, a variety that performs well in one region may not necessarily exhibit the same potential under different agro-climatic conditions. Hence, it is essential to understand the adaptability and suitability of each variety to specific local environments and management practices. Since cultivars differ in their growth habit, duration and physiological responses, their optimal plant spacing and agronomic requirements also vary.

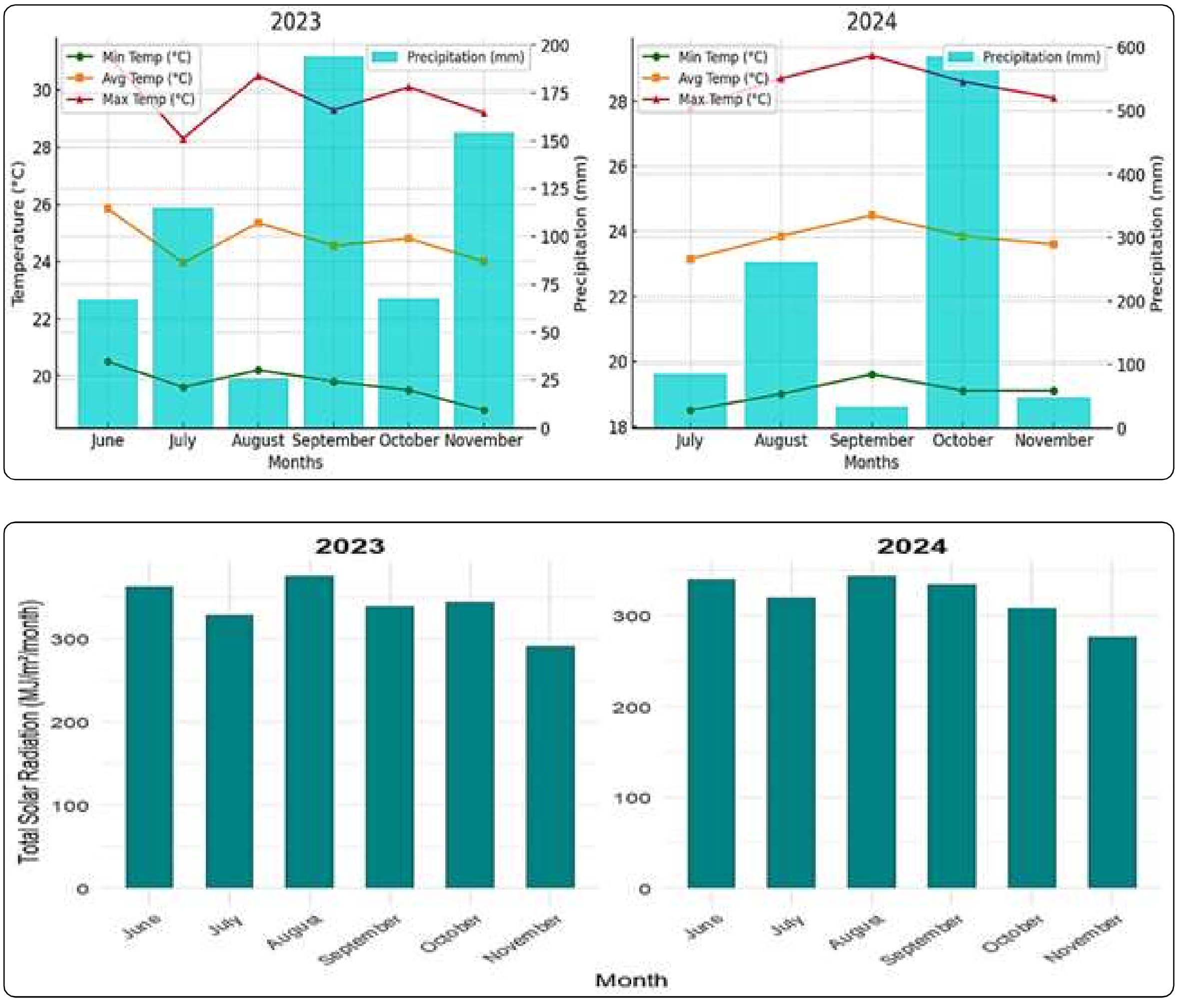


Fig. 1 : Monthly changes in temperature, total precipitation and total solar radiation during groundnut growing season at GKVK, Bengaluru station in 2023-2024

The formation, accumulation and movement of metabolites to yield-contributing plant parts are largely governed by the genotype and prevailing environmental condition. Crop yield, therefore, results from the combined interaction of plant genetics, soil characteristics, environmental factors and agronomic management. By modifying the crop's immediate environment (microclimate) through appropriate agronomic practices, it is possible to enhance the efficient use of available resources and thereby increase productivity. Thus, realizing maximum yield depends on providing favourable growing conditions through the selection of suitable varieties and proper management strategies aimed at improving the production potential of crops.

Several studies have shown that crop genotypes are highly sensitive to seasonal variations and location-specific factors and their performance differs with soil type and cultivation methods such as irrigated or rainfed condition. Therefore, understanding the specific requirements and adaptability of each genotype in a given locality is crucial for determining the most effective planting geometry and achieving optimal yields.

Varieties differed significantly with respect to pod and haulm yield (Table 2). The variety, K-1812 produced significantly higher pod and haulm yield (3603 kg ha$^{-1}$) than KCG-6 (2181 kg ha$^{-1}$) and K-6 (208kg ha$^{-1}$). The significantly higher yield in K-1812

**Table 1**

**Pod yield (kg ha$^{-1}$), haulm yield (kg ha$^{-1}$), harvest index and WUE as influenced by varieties and date of sowing in groundnut**

| Treatments | Pod yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) | Harvest index | WUE (kg ha-mm$^{-1}$) |
|---|---|---|---|---|
| $V_1$ (KCG-6) | 2181 | 8361 | 0.22 | 3.92 |
| $V_2$ (K-1812) | 3603 | 9489 | 0.28 | 6.61 |
| $V_3$ (K-6) | 2080 | 8821 | 0.24 | 3.74 |
| F test | ** | * | ** | ** |
| S. Em. ± | 91 | 261 | 0.006 | 0.16 |
| CD @ 5% | 274 | 787 | 0.020 | 0.48 |
| D: Date of sowing | | | | |
| $D_1$ (June 2$^{nd}$ fortnight) | 2443 | 9162 | 0.21 | 4.79 |
| $D_2$ (July 1$^{st}$ fortnight) | 2799 | 8619 | 0.28 | 4.72 |
| F test | ** | NS | ** | NS |
| S. Em. ± | 74 | 213 | 0.005 | 0.13 |
| CD @ 5% | 224.0 | NS | 0.016 | NS |
| Interaction | | | | |
| $D_1V_1$ | 1921 | 9194 | 0.17 | 3.78 |
| $D_2V_1$ | 2441 | 7528 | 0.26 | 4.06 |
| $D_1V_2$ | 3510 | 9976 | 0.26 | 6.90 |
| $D_2V_2$ | 3696 | 9003 | 0.29 | 6.33 |
| $D_1V_3$ | 1899 | 8316 | 0.19 | 3.68 |
| $D_2V_3$ | 2261 | 9326 | 0.30 | 3.79 |
| F test | NS | ** | ** | NS |
| S. Em. ± | 128 | 369 | 0.009 | 0.22 |
| CD @ 5% | NS | 1113 | 0.028 | NS |

than KCG-6 and K-6 was mainly due to significantly higher growth and yield attributing components. The difference in pod yield of groundnut varieties was also reported by Mukhtar *et al*. (2013), Babitha *et al*. (2017) and Naik *et al*. (2018).

The variety K-1812 recorded the higher harvest index of 0.28, followed by K-6 (0.24) and KCG-6 (0.22). Although KCG-6 produced the higher pod and haulm yield, it recorded the lower harvest index (0.22), indicating that a larger proportion of its biomass was allocated to vegetative growth. In contrast, K-1812, despite having lower absolute pod and haulm yield, recorded the higher harvest index (0.28), suggesting better partitioning efficiency of assimilates towards reproductive parts. KCG-6 showed an intermediate harvest index (0.22), balancing both biomass and economic yield. These differences highlight varietal variability in biomass allocation and yield efficiency.

The variety K-1812 recorded the higher water use efficiency (WUE) of 6.61 kg ha-mm$^{-1}$, followed by KCG-6 (3.92 kg ha-mm$^{-1}$) and K-6 (3.74 kg ha-mm$^{1}$). Water Use Efficiency (WUE) reflects the crop's ability to convert water into yield. Among the tested varieties, K-1812 exhibited the higher WUE, indicating its

**Table 2**

**Total dry matter (g) production per plant in groundnut as influenced by varieties and date of sowing**

| Treatment | Phenophases | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | Flower initiation | 50% flowering | Pod initiation | Pod filling | Harvest |
| | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| V: Varieties | | | | | | |
| $V_1$: KCG-6 | 2.58 | 5.01 | 7.59 | 18.2 | 36.5 | 73.2 |
| $V_2$: K-1812 | 3.33 | 5.89 | 8.75 | 21.4 | 44.4 | 92.3 |
| $V_3$: K-6 | 2.46 | 4.66 | 7.14 | 16.5 | 35.3 | 64.7 |
| F test | NS | ** | ** | ** | ** | ** |
| S. Em. ± | 0.13 | 0.11 | 0.25 | 0.48 | 0.55 | 1.69 |
| CD @ 5% | 0.40 | 0.33 | 0.75 | 1.44 | 1.67 | 5.08 |
| D: Date of sowing | | | | | | |
| $D_1$: June 2nd fortnight | 3.04 | 5.53 | 8.36 | 19.9 | 40.1 | 79.8 |
| $D_2$: July 1 st fortnight | 2.53 | 4.85 | 7.29 | 17.6 | 37.4 | 73.8 |
| F test | NS | ** | ** | ** | ** | ** |
| S. Em. ± | 0.11 | 0.09 | 0.20 | 0.39 | 0.45 | 1.38 |
| CD @ 5% | 0.33 | 0.27 | 0.61 | 1.18 | 1.36 | 4.15 |
| Interaction | | | | | | |
| $D_1V_1$ | 2.92 | 5.45 | 8.03 | 19.0 | 38.5 | 76.2 |
| $D_2V_1$ | 2.23 | 4.57 | 7.15 | 17.4 | 34.5 | 70.2 |
| $D_1V_2$ | 3.35 | 5.98 | 9.05 | 22.3 | 43.9 | 92.9 |
| $D_2V_2$ | 3.31 | 5.80 | 8.44 | 20.6 | 45.0 | 91.8 |
| $D_1V_3$ | 2.86 | 5.15 | 7.99 | 18.2 | 37.8 | 70.1 |
| $D_2V_3$ | 2.06 | 4.18 | 6.28 | 14.8 | 32.7 | 59.3 |
| F test | NS | * | NS | NS | ** | NS |
| S. Em. ± | 0.19 | 0.15 | 0.35 | 0.68 | 0.78 | 2.39 |
| CD @ 5% | NS | 0.46 | NS | NS | 2.36 | NS |

superior capacity to utilize available water more effectively for pod production. This higher WUE can be attributed to its greater pod yield relative to the water used. In contrast, K-6 recorded lower WUE, suggesting relatively less efficient water utilization. KCG-6 showed moderate WUE.

Higher pod and haulm yield of groundnut is directly related to the total dry matter production (Table 2). Significantly higher total dry matter production was observed with K-1812 (3.33, 5.89, 8.75, 21.49, 44.49 and 92.3 g plant-1 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest ,respectively) compared to KCG-6 (2.58, 5.01, 7.59, 18.24, 36.52 and 72.23 g plant-1 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively) and K-6 (2.46, 4.66, 7.14, 16.57, 35.31 and 64.78 g plant-1 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively). Total dry matter is the

**TABLE 3**

**Leaf area (cm² plant⁻¹) of groundnut as influenced by varieties and date of sowing**

| Treatment | Phenophases | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | Flower initiation | 50% flowering | Pod initiation | Pod filling | Harvest |
| | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| V: Varieties | | | | | | |
| $V_1$: KCG-6 | 364.8 | 445.2 | 532.5 | 1061 | 1133 | 85.85 |
| $V_2$: K-1812 | 409.2 | 512.6 | 644.4 | 1289 | 1607 | 287.9 |
| $V_3$: K-6 | 311.7 | 441.5 | 521.3 | 897.1 | 1025 | 179.7 |
| F test | ** | ** | ** | ** | ** | ** |
| S. Em. ± | 15.61 | 8.42 | 18.44 | 55.47 | 70.12 | 14.12 |
| CD @ 5% | 47.05 | 25.38 | 55.59 | 167.2 | 211.4 | 42.56 |
| D: Date of sowing | | | | | | |
| $D_1$: June 2nd fortnight | 385.2 | 484.5 | 603.6 | 1169 | 1394 | 207.8 |
| $D_2$: July 1 st fortnight | 338.6 | 448.4 | 528.5 | 995.9 | 1116 | 161.1 |
| F test | * | ** | ** | * | ** | * |
| S. Em. ± | 12.74 | 6.87 | 15.06 | 45.29 | 57.25 | 11.53 |
| CD @ 5% | 38.41 | 20.72 | 45.39 | 136.5 | 172.6 | 34.75 |
| Interaction | | | | | | |
| $D_1V_1$ | 381.7 | 464.7 | 566.1 | 1098 | 1196 | 90.70 |
| $D_2V_1$ | 348.0 | 425.8 | 498.9 | 1025 | 1071 | 81.00 |
| $D_1V_2$ | 429.4 | 516.1 | 680.5 | 1374 | 1787 | 303.4 |
| $D_2V_2$ | 389.0 | 509.1 | 608.3 | 1203 | 1427 | 272.5 |
| $D_1V_3$ | 344.5 | 472.7 | 564.3 | 1034 | 1199 | 229.4 |
| $D_2V_3$ | 278.9 | 410.4 | 478.3 | 759.7 | 851.3 | 130.0 |
| F test | NS | NS | NS | NS | NS | NS |
| S. Em. ± | 22.07 | 11.91 | 26.08 | 78.44 | 99.17 | 19.97 |
| CD @ 5% | NS | NS | NS | NS | NS | NS |

spatial and temporal integration of all plant processes. Pattern of dry matter accumulation rate of a crop typically follow the sigmoid curve.

Nazir *et al*. (2022) and Vyshnavi *et al.* (2023) observed significant variation among groundnut varieties in total dry matter production. However, total dry matter alone does not determine varietal efficiency; rather, the proportion allocated to reproductive structures serves as a better indicator of performance. Analysis of dry matter partitioning revealed that at pod initiation, pod filling and harvest stages, the variety K-1812 accumulated more dry matter in root, stem and leaves than KCG-6 and K-6.

The production and distribution of dry matter among plant parts are influenced by the plant's photo synthetic efficiency at different growth stages. This photosynthetic capacity, in turn, depends on the accumulation of photosynthates in the leaves, as well as on leaf number and leaf area.

TABLE 4

**Number of branches per plant as influenced by varieties and date of sowing in groundnut**

| Treatment | Phenophases | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | Flower initiation | 50% flowering | Pod initiation | Pod filling | Harvest |
| | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| V: Varieties | | | | | | |
| $V_1$: KCG-6 | 3.94 | 4.34 | 4.47 | 4.82 | 8.05 | 8.90 |
| $V_2$: K-1812 | 6.10 | 6.60 | 6.82 | 7.92 | 10.7 | 11.5 |
| $V_3$: K-6 | 4.72 | 5.07 | 5.30 | 5.93 | 9.17 | 10.0 |
| F test | ** | ** | ** | ** | * | * |
| S. Em. ± | 0.15 | 0.20 | 0.23 | 0.26 | 0.56 | 0.54 |
| CD @ 5% | 0.44 | 0.61 | 0.69 | 0.79 | 1.69 | 1.64 |
| D: Date of sowing | | | | | | |
| $D_1$: June $2^{nd}$ fortnight | 4.87 | 5.18 | 5.40 | 6.01 | 9.10 | 9.99 |
| $D_2$: July $1^{st}$ fortnight | 4.97 | 5.49 | 5.66 | 6.44 | 9.51 | 10.3 |
| F test | NS | NS | NS | NS | NS | NS |
| S. Em. ± | 0.12 | 0.16 | 0.19 | 0.21 | 0.46 | 0.44 |
| CD @ 5% | NS | NS | NS | NS | NS | NS |
| Interaction | | | | | | |
| $D_1V_1$ | 3.71 | 4.00 | 4.09 | 4.45 | 7.68 | 8.63 |
| $D_2V_1$ | 4.16 | 4.68 | 4.86 | 5.20 | 8.43 | 9.18 |
| $D_1V_2$ | 6.41 | 6.67 | 6.96 | 7.75 | 10.7 | 11.5 |
| $D_2V_2$ | 5.79 | 6.54 | 6.68 | 8.09 | 10.6 | 11.4 |
| $D_1V_3$ | 4.50 | 4.88 | 5.16 | 5.82 | 8.90 | 9.75 |
| $D_2V_3$ | 4.95 | 5.25 | 5.44 | 6.03 | 9.44 | 10.2 |
| F test | * | NS | NS | NS | NS | NS |
| S. Em. ± | 0.21 | 0.28 | 0.33 | 0.37 | 0.79 | 0.77 |
| CD @ 5% | 0.63 | NS | NS | NS | NS | NS |

The magnitude of photosynthetic ability of the crop is more meaningfully interpreted in terms of leaf area per plant (Table 3), number of branches per plant (Table 4), SPAD values (Table 5). To obtain higher dry matter, photosynthetic efficiency of leaf area is very much essential. Significantly higher leaf area was observed with K-1812 (409.2, 512.6, 644.4, 1289, 1607 and 287.9 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively) compared to KCG-6 (364.8, 445.2, 532.5, 1061,1133 and 85.85 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively) and K-6 (311.7, 441.5, 521.3, 897.1, 1025 and 179.7 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively). Leaf area mainly depends on the higher number of branches (Table 4). Significantly higher number of branches per plant (6.10, 6.60, 6.82, 7.92, 10.70 and 11.53 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod

**TABLE 5**

**Plant height (cm) as influenced by varieties and date of sowing in groundnut**

| Treatment | Phenophases | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | Flower initiation | 50% flowering | Pod initiation | Pod filling | Harvest |
| | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| V: Varieties | | | | | | |
| $V_1$: KCG-6 | 19.11 | 22.04 | 29.60 | 35.67 | 39.02 | 54.20 |
| $V_2$: K-1812 | 16.22 | 16.90 | 23.71 | 26.64 | 29.79 | 40.66 |
| $V_3$: K-6 | 17.04 | 19.58 | 26.66 | 30.58 | 33.51 | 45.77 |
| F test | ** | ** | ** | ** | ** | ** |
| S. Em. ± | 0.38 | 0.41 | 0.62 | 1.14 | 0.64 | 1.15 |
| CD @ 5% | 1.14 | 1.24 | 1.86 | 3.43 | 1.94 | 3.49 |
| D: Date of sowing | | | | | | |
| $D_1$: June 2nd fortnight | 17.06 | 18.71 | 25.53 | 29.22 | 32.38 | 44.41 |
| $D_2$: July 1 st fortnight | 17.85 | 20.31 | 27.78 | 32.71 | 35.83 | 49.35 |
| F test | NS | ** | ** | * | ** | ** |
| S. Em. ± | 0.31 | 0.34 | 0.50 | 0.93 | 0.53 | 0.94 |
| CD @ 5% | NS | 1.01 | 1.52 | 2.80 | 1.58 | 2.85 |
| Interaction | | | | | | |
| $D_1V_1$ | 18.33 | 21.59 | 28.06 | 33.84 | 36.51 | 50.46 |
| $D_2V_1$ | 19.89 | 22.50 | 31.14 | 37.51 | 41.53 | 57.94 |
| $D_1V_2$ | 16.15 | 16.26 | 22.65 | 24.54 | 28.88 | 38.90 |
| $D_2V_2$ | 16.28 | 17.54 | 24.78 | 28.75 | 30.70 | 42.43 |
| $D_1V_3$ | 16.69 | 18.28 | 25.89 | 29.28 | 31.76 | 43.86 |
| $D_2V_3$ | 17.38 | 20.89 | 27.44 | 31.88 | 35.25 | 47.68 |
| F test | NS | NS | NS | NS | NS | NS |
| S. Em. ± | 0.53 | 0.58 | 0.87 | 1.61 | 0.91 | 1.63 |
| CD @ 5% | NS | NS | NS | NS | NS | NS |

filling and harvest, respectively) were noticed in K-1812 compared to KCG-6 and K-6. Significantly higher plant height was recorded in KCG-6 (19.11, 22.04, 29.60, 35.67, 39.02 and 54.20 cm at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively) compared to K-1812 (16.22, 16.90, 23.71, 26.64, 29.79 and 40.66 cm) and K-6 (17.04, 19.58, 26.66, 30.58, 33.51 and 45.77 cm) at corresponding growth stages. (Table 5). Higher SPAD values were recorded in K-6 (57.31, 70.74, 72.29, 66.33, 40.71 and 36.31 at 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest, respectively) compared to K-1812 (53.94, 67.90, 70.64, 62.50, 42.06 and 35.10) and KCG-6 (52.81, 67.43, 69.99, 65.07, 45.19 and 34.69) at the respective stages (Table 7). These results were conformity with Dileep *et al.* (2021) and Chandini *et al.* (2022) in groundnut.

TABLE 6

**SPAD Values (chlorophyll content) as influenced by varieties and date of sowing in groundnut**

| Treatment | Phenophases | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | Flower initiation | 50% flowering | Pod initiation | Pod filling | Harvest |
| | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| V: Varieties | | | | | | |
| $V_1$: KCG-6 | 52.81 | 67.43 | 69.99 | 65.07 | 45.19 | 34.69 |
| $V_2$: K-1812 | 53.94 | 67.90 | 70.64 | 62.50 | 42.06 | 35.10 |
| $V_3$: K-6 | 57.31 | 70.74 | 72.29 | 66.33 | 40.71 | 36.31 |
| F test | NS | NS | NS | * | NS | NS |
| S. Em. ± | 1.24 | 1.31 | 0.63 | 0.86 | 1.22 | 0.72 |
| CD @ 5% | NS | NS | NS | 2.60 | NS | NS |
| D: Date of sowing | | | | | | |
| $D_1$: June 2nd fortnight | 53.67 | 68.83 | 71.99 | 64.13 | 43.58 | 36.34 |
| $D_2$: July 1 st fortnight | 55.70 | 68.55 | 69.95 | 65.13 | 41.73 | 34.39 |
| F test | NS | NS | * | NS | NS | * |
| S. Em. ± | 1.01 | 1.07 | 0.51 | 0.70 | 0.99 | 0.59 |
| CD @ 5% | NS | NS | 1.55 | NS | NS | 1.78 |
| Interaction | | | | | | |
| $D_1V_1$ | 51.01 | 68.19 | 72.29 | 65.34 | 46.84 | 34.89 |
| $D_2V_1$ | 54.61 | 66.68 | 67.69 | 64.80 | 43.55 | 34.49 |
| $D_1V_2$ | 52.84 | 66.51 | 70.33 | 60.86 | 44.79 | 36.24 |
| $D_2V_2$ | 55.04 | 69.29 | 70.95 | 64.14 | 39.33 | 33.96 |
| $D_1V_3$ | 57.15 | 71.78 | 73.36 | 66.20 | 39.10 | 37.90 |
| $D_2V_3$ | 57.46 | 69.70 | 71.23 | 66.46 | 42.33 | 34.71 |
| F test | NS | NS | * | NS | NS | NS |
| S. Em. ± | 1.75 | 1.85 | 0.89 | 1.22 | 1.72 | 1.02 |
| CD @ 5% | NS | NS | 2.69 | NS | NS | NS |

**Effect of Sowing Dates on Growth, Dry Mater Partitioning and Yield**

Sowing time serves as a crucial non-monetary input for achieving successful crop production. Optimum crop growth and development can be realized only when sowing is done at the appropriate time, ensuring that environmental conditions are favourable for plant growth. Significant variation in groundnut pod yield and haulm yield was observed as influenced by sowing dates (Tables 1). Sowing during the July 1st fortnight recorded a notably higher pod yield (2799 kg $ha^{-1}$) compared to the June 2nd fortnight (2443 kg $ha^{-1}$). However, haulm yield did not differ significantly between sowing dates, with pooled yield of 8619 kg $ha^{-1}$ for July 1st fortnight and 9162 kg $ha^{-1}$ for June 2nd fortnight.

**Table 7**

**Influence of varieties and sowing date on economics in groundnut**

| Treatments | Gross returns (Rs. $ha^{-1}$) | Net returns (Rs. $ha^{-1}$) | B:C |
|---|---|---|---|
| V : Varieties | | | |
| $V_1$: KCG-6 | 130840 | 70793 | 69.99 |
| $V_2$: K-1812 | 216168 | 156340 | 70.64 |
| $V_3$: K-6 | 124788 | 64960 | 72.29 |
| F test | ** | ** | NS |
| S. Em. ± | 5461.0 | 5406.0 | 0.63 |
| CD @ 5% | 16460 | 16294 | NS |
| D: Date of sowing | | | |
| $D_1$: June 2nd fortnight | 146579 | 86605 | 71.99 |
| $D_2$: July 1 st fortnight | 167952 | 108124 | 69.95 |
| F test | ** | ** | * |
| S. Em. ± | 4459.0 | 4414.0 | 0.51 |
| CD @ 5% | 13440 | 13304 | 1.55 |
| Interaction | | | |
| $D_1V_1$ | 115243 | 54978 | 72.29 |
| $D_2V_1$ | 146437 | 86609 | 67.69 |
| $D_1V_2$ | 210579 | 150751 | 70.33 |
| $D_2V_2$ | 221758 | 161930 | 70.95 |
| $D_1V_3$ | 113914 | 54086 | 73.36 |
| $D_2V_3$ | 135662 | 75834 | 71.23 |
| F test | NS | NS | * |
| S. Em. ± | 7722.0 | 7645.0 | 0.89 |
| CD @ 5% | NS | NS | 2.69 |

A significantly greater harvest index was observed for groundnut sown in July 1st fortnight (0.28) compared to June 2nd fortnight sowing (0.21), reflecting superior partitioning of assimilates towards economic yield. This increased harvest index aligns with the improvement in pod yield during July 1st fortnight sowing.

This was due to the higher value of yield and growth components. Kanade *et al*. (2015) reported that sowing groundnut on 6th July significantly improved various growth and yield parameters compared to earlier and later sowing dates such as 22nd June, 29th June, 13th July and 20th July. Similar results were also recorded by Sarkees (2015), Mohite *et al*. (2017) and Kumar *et al*. (2020).

Water use efficiency (WUE) did not show significant changes between the tested sowing dates. The pooled WUE values were 4.72 kg ha-$mm^{-1}$ for July 1st fortnight and 4.79 kg ha-$mm^{-1}$ for June 2nd fortnight, indicating that efficient conversion of water into economic yield remained consistent regardless of the sowing window selected. This is closely associated with the grain yield per hectare (Table 1).

The higher pod and haulm yield of groundnut is directly related to the total dry matter production

(Table 2). Significant variation in total dry matter production per plant was observed in groundnut as influenced by sowing dates at different phenophases. Sowing at June 2nd fortnight recorded significantly higher total dry matter production at all stages compared to July 1st fortnight. The total dry matter production for June 2nd fortnight was 3.04, 5.53, 8.36, 19.9, 40.1 and 79.8 g plant$^{-1}$ at 30 days after sowing, flower initiation, 50% flowering, pod initiation, pod filling and harvest stages, respectively, whereas July 1st fortnight sowing recorded 2.53, 4.85, 7.29, 17.6, 37.4 and 73.8 g plant$^{-1}$, respectively at these stages.

These results indicated that sowing in the June 2nd fortnight enhances total dry matter production throughout all growth stages in groundnut, resulting in increased biomass accumulation in leaves, stems and pods. Delayed sowing in the July 1st fortnight reduces dry matter production.

The observed results can be attributed primarily to the shortened growth period in later sowing dates, which was associated with higher temperature and lower rainfall. In contrast, early sowing provided a relatively cooler environment during pod development, coupled with adequate soil moisture and an extended pod-filling period, allowing greater accumulation of photosynthates in the pods and consequently, higher pod weight. These findings are in agreement with the reports of Salih (1990), Mligo and Craufurd (2005), Kumar *et al*. (2008), Anilrao *et al.* (2024) and Rani and Raji Reddy (2010).

The production and distribution of dry matter in different plant parts is largely determined by the photosynthetic capacity of the plant at various growth stages. This capacity depends on factors such as photosynthate accumulation in leaves, leaf number and leaf area. The photosynthetic potential of the crop is more effectively assessed through parameters like leaf area per plant (Table 3) and number of branches per plant (Table 4). Dry matter accumulation is closely related to LAI, highlighting that achieving higher dry matter requires efficient photosynthetic utilization of the leaf area.

Significant differences were observed in leaf area (Table 3) and plant height (Table 5) of groundnut as influenced by sowing dates at various phenophases. Sowing during June 2nd fortnight resulted in higher leaf area per plant compared to July 1st fortnight at all growth stages. Specifically, leaf area per plant during June 2nd fortnight sowing measured 385.2, 484.5, 603.6, 1169, 1394 and 207.8 cm$^2$ at 30 days after sowing, flower initiation, 50% flowering, pod initiation, pod filling and harvest stages, respectively, while July 1st fortnight sowing recorded lower measurements of 338.6, 448.4, 528.5, 995.9, 1116 and 161.1 cm$^2$, respectively at the same stages. The higher leaf area under June 2nd fortnight sowing suggest better canopy development and light interception, promoting greater photo synthetic capacity.

Number of branches per plant did not show significant differences between the two sowing dates across all phenophases, indicating that branching was relatively stable despite changes in sowing time. The number of branches ranged from 4.87 to 9.99 for June 2nd fortnight sowing and 4.97 to 10.3 for July 1st fortnight sowing from 30 days after sowing to harvest stage (Table 4).

Plant height was consistently greater for July 1st fortnight sowing at all phenophases. At 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest stages, plant height for July 1st fortnight sowing were 17.85, 20.31, 27.78, 32.71, 35.83 and 49.35 cm, respectively compared to 17.06, 18.71, 25.53, 29.22, 32.38 and 44.41 cm, respectively for June 2nd fortnight sowing (Table 5). Despite having lower leaf area, the increased plant length with July 1st fortnight sowing might reflect an elongated growth pattern under delayed planting.

SPAD values, indicating chlorophyll content, were generally comparable between sowing dates. At 30 days after sowing, June 2nd fortnight sowing showed a SPAD of 53.67 compared to 55.70 for July 1st fortnight. Values during flower initiation and 50% flowering stages ranged from 68.83 to 71.99 for June 2nd fortnight and 68.55 to 69.95 for July

1st fortnight, with minor variations and no significant differences at later stages (Table 6).

In summary, the larger leaf area under June 2nd fortnight sowing enhanced canopy development and photosynthetic potential. Although July 1st fortnight sowing resulted in slightly longer plants, it had a smaller canopy size, stable number of branches, comparable chlorophyll content and similar growth rates across sowing dates suggest that sowing mainly affected canopy architecture and plant length without changing overall growth dynamics.

**Interaction of Varieties and Date of Sowing on Growth, Dry Mater Partitioning and Yield**

Analysis of pod yield and water use efficiency (WUE) revealed no significant difference among the treatments. In contrast, haulm yield showed a significant variation, with the higher value recorded in $D_1V_2$ (9976 kg $ha^{-1}$), while harvest index also differed significantly, with the maximum in $D_2V_3$ (0.30). (Table 1).

Total dry matter production per plant showed no significant difference among the treatments at 30 DAS, 50% flowering, pod initiation and harvest. At flower initiation, a significant difference was observed, with the higher dry matter recorded in $D_1V_2$ (5.89 g). Similarly, at pod filling, significant variation was noted and the maximum dry matter accumulation was observed in $D_2V_2$ (44.4 g) (Table 2).

The interaction between sowing date and varieties did not significantly affect leaf area per plant at all phenophases, including 30 DAS, flower initiation, 50% flowering, pod initiation, pod filling and harvest. Similarly, plant height showed no significant differences among interactions across all phenophases (Table 3 & 4).

The number of branches per plant was non-significant, except at 30 DAS, where the higher value was recorded in $D_1V_2$ (6.41 branches per plant) (Table 4).

SPAD values differed significantly among interactions only at 50% flowering, with the higher value observed in $D_1V_3$ (73.36). At all other phenophases the differences were non-significant (Table 6).

**Effect of Varieties and Sowing Dates on Economics in Groundnut**

The primary objective of any agricultural practice or technology is to achieve the higher returns per unit of investment. This approach also helps to identify the optimal sowing time, plant population and cultivar for maximizing net profit.

For a farming technology to be recommended under practical conditions, it must demonstrate economic viability, reflected in higher net returns and an advantageous benefit-cost (B:C) ratio. Accordingly, the cost of cultivation, gross returns, net returns and B:C ratio for different groundnut varieties and sowing dates are presented and discussed in this section.

Significant differences were observed in gross return, net return and benefit-cost (B:C) ratio among groundnut varieties and sowing dates (Table 7).

Among varieties, K-1812 recorded the higher gross returns of Rs.216,168 $ha^{-1}$, significantly outperforming KCG-6 (Rs.130,840 $ha^{-1}$) and K-6 (Rs.124,788 $ha^{-1}$). Net returns followed the same pattern, with K-1812 generating Rs.156,340 $ha^{-1}$, compared to Rs.70,793 $ha^{-1}$ for KCG-6 and Rs.64,960 $ha^{-1}$ for K-6. The B:C was higher for K-1812 at 3.41, indicating better economic efficiency, followed by 2.07 and 1.97 for KCG-6 and K-6, respectively.

Among sowing dates, July 1st fortnight resulted in higher gross returns (Rs.167,952 $ha^{-1}$) and net returns (Rs.108,124 $ha^{-1}$) than the June 2nd fortnight (Rs.146,579 $ha^{-1}$ gross returns and Rs.86,605 $ha^{-1}$ net return). The B:C was also higher in July 1st fortnight sowing (2.65) compared to June 2nd fortnight sowing (2.31).

The interaction between date of sowing and varieties was non-significant for gross returns, net returns and B:C ratio, indicating that none of the treatment combinations differed significantly for these economic parameters.

Overall, the variety K-1812 with sowing in the July 1st fortnight s is the most economically viable combination, providing the higher returns and profitability. Similar results were reported by Singh *et al*. (2018) and kumar *et al.* (2021)

The study clearly demonstrated that varietal selection and sowing time exert significant influence on growth, dry matter accumulation, yield and profitability of groundnut under rainfed conditions of the Eastern Dry Zone of Karnataka. Among the three varieties tested, K-1812 proved superior, producing the highest pod yield, haulm yield, total dry matter, leaf area and water use efficiency across both seasons. Sowing during the July 1st fortnight enhanced pod yield and harvest index, whereas the June 2nd fortnight favoured greater dry matter accumulation and canopy development.

Interaction effects between varieties and sowing dates were largely non-significant, indicating that varietal responses were relatively stable across sowing windows. Economic evaluation further confirmed that K-1812 sown in the July 1st fortnight generated the highest gross returns, net returns and B:C ratio, making it the most profitable option for farmers.

Overall, the results suggest that adopting K-1812 with July 1st fortnight sowing is the most effective strategy for maximizing productivity and economic returns of rainfed groundnut.

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