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Influence of planting geometry on growth, yield and nutrient uptake of groundnut (*Arachis hypogaea* L.) cultivars under broad bed and furrow system

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Abstract
A field study on "Influence of Planting Geometry on Growth, yield and Nutrient Uptake of Groundnut (*Arachis hypogaea* L.) under Broad Bed and Furrow System" was conducted during *rabi* season of 2022-23 at the research field of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. The experiment was laid out with 2 × 4 factorial randomised block design with three replications on broad bed furrow. Total sixteen treatment combinations consisted of four planting geometries: 30 cm × 10 cm (P1), 15:15 cm × 10 cm (P2), 20:20 cm × 10 cm (P3), 25:25 cm × 10 cm (P4) in paired row was the first factor and second factor includes four genotypes which were Girnar 4 (V1), Girnar 5 (V2), Avtar (V3), K6 (V4). Among the planting geometries, leaf area index, dry matter production was significantly higher in 25:25 × 10 cm while number of branches plant^{-1} was found non-significant. Pod yield and nutrient uptake was significantly influenced by 25:25 × 10 cm planting geometry as compared to the other planting geometries. Among the varieties studied, Girnar 5 variety recorded higher plant height, leaf area index, dry matter production, yield and nutrient uptake and it was on par with Girnar 4. From this investigation it can be concluded that, among the planting geometries, 25:25 × 10 cm spacing found best compared to other planting geometries and among the varieties studied Girnar 5 and Girnar 4 varieties were found best among varieties studied.

Keywords: Broad bed furrows, groundnut genotypes, planting geometries, growth, yield, nutrient uptake

1. Introduction

Groundnut (*Arachis hypogaea* L.) is a major oilseed crop of global importance and a key contributor to the Indian agricultural economy. It belongs to the family Fabaceae (Leguminaceae) and its name is derived from the Greek words *Arachis* (legume) and *hypogaea* (below ground), reflecting its unique geocarpic nature. The kernels contain 40–50% oil and are widely used for edible purposes, besides being a rich source of vitamins A, B and E. As a leguminous crop, groundnut also plays an important role in improving soil fertility through biological nitrogen fixation, making it a valuable component in crop rotations (Kamdi *et al.*, 2024) [16]. Globally, groundnut is cultivated over 29.5 million hectares with a production of 48.7 million tonnes and an average productivity of about 1.6 t ha^{-1} (FAOSTAT, 2019) [8]. Developing countries dominate its cultivation, contributing nearly 97% of the total area and 94% of production. India occupies a prominent position with 55.71 lakh hectares under cultivation and a production of 102 lakh tonnes (2020–21), with an average productivity of 1831 kg ha^{-1} (Groundnut Outlook Report, 2020-21). However, productivity in Telangana (837 kg ha^{-1}) remains considerably lower than the national average, indicating substantial scope for improvement through appropriate agronomic interventions. In Telangana, groundnut is cultivated during *kharif, rabi* and *summer* seasons, of which *rabi* has emerged as the most reliable due to assured irrigation, favourable temperature and adequate sunshine. In contrast, *kharif* cultivation is often constrained by erratic monsoon, intermittent dry spells and incidence of foliar diseases, leading to unstable yields (Sawargaonkar *et al.*, 2024) [22]. Consequently, there has been a gradual shift towards *rabi* cultivation, which generally ensures higher and more stable productivity.

Among the various agronomic practices, planting geometry plays a pivotal role in determining crop growth and yield by regulating plant population, canopy structure and resource use efficiency (Sawargaonkar *et al.*, 2025) [25]. Paired row planting, which accommodates two rows on either side of a furrow, has been recognized as an efficient planting technique for improving water and nutrient use. This system enhances aeration, light penetration and overall canopy development, thereby optimizing photosynthetic efficiency. Findings from the All India Coordinated Research Project on Groundnut have demonstrated the superiority of paired row planting over conventional methods. Furthermore, the broad bed furrow (BBF) system improves soil physical properties by reducing bulk density and enhancing aeration, which are essential for effective peg penetration and pod development in groundnut (Kamdi *et al.*, 2023) [15]. Increased yields under BBF have been reported in studies conducted at ICRISAT and other locations (Vekariya *et al.*, 2015; Kamble *et al.*, 2016) [28, 13]. Despite its importance, groundnut productivity in India is often constrained by cultivation under rainfed conditions, erratic rainfall distribution, lack of improved varieties and susceptibility to diseases such as rust, tikka, and bud necrosis (Sawargaonkar *et al.*, 2025) [25]. Therefore, enhancing productivity requires the integration of suitable high-yielding cultivars with optimum planting geometry and nutrient management practices. Among these, variety and spacing are critical factors influencing plant growth, yield attributes, nutrient uptake and overall productivity (Gawas *et al.*, 2020) [9].

2. Materials and Methods

The field experiment was conducted during the *rabi* season of 2022–23 in the field No. RP 7C Latitude: 17° 31' 48.00" N Longitude: 78° 16' 12.00" E, at ICRISAT, Hyderabad, India. Before sowing, composite soil samples were collected from 0–30 cm depth at random locations across the experimental field to determine the physico-chemical properties. The soil was sandy loam in texture, neutral in reaction (pH 7.89), low in available nitrogen and phosphorus and medium to high in available potassium. The experiment was laid out with 2 × 4 factorial randomised block design with three replications. There were two factors, one factor includes four planting geometries, 30 cm × 10 cm (P1), 15:15 cm × 10 cm (P2), 20:20 cm × 10 cm (P3), 25:25 cm × 10 cm (P4) in paired row planting and second factor includes four varieties which were (V1) Girnar 4, (V2) Girnar 5, (V3) Avtar, (V4) K6. Girnar 4 (V1), Girnar 5 (V2), Avtar (V3) these three varieties are developed at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and K6 (V4) developed at Agricultural Research Station (ARS), Anantapur. In case of planting geometries, the total plant population on a bed (furrow to furrow distance is 1.5 m and net planting bed area is 1.2 m) was same having four rows per bed whereas the spacing between two pairs in P2 is 60 cm, P3 is 50 cm and P4 is 40 cm (Fig. 1).The crop was grown on broad bed furrows (BBF), with a bed width of 1.2 m and a furrow-to-furrow distance of 1.5 m, maintaining four rows per bed across all treatments. The spacing between paired rows varied as per treatments, with inter-row spacing of 60 cm, 50 cm and 40 cm in P2, P3 and P4, respectively, while maintaining uniform plant population per bed.

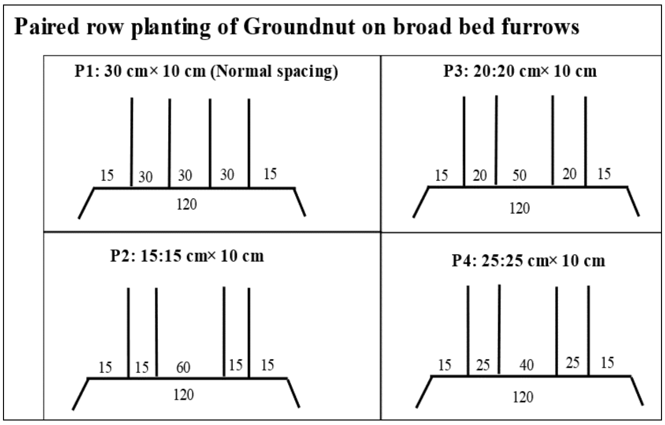

Fig 1: Paired row planting of four rows of groundnut on broad bed furrows

The field was ploughed to a depth of 30 cm and brought to a fine tilth through successive harrowings. Broad bed furrows were formed using a tractor-drawn ridger as per the experimental layout.

Fertilizer dose of 20 kg nitrogen ha^{-1} was given in the form of urea, 40 kg ha^{-1} of phosphorus through single super phosphate and 50 kg ha^{-1} of potassium through muriate of potash. The fertilizer was applied along the marked lines 5 cm below the soil surface before sowing.

2.1 Growth parameters

2.1.1 Plant height

The height of the five randomly selected plants was measured from the ground level to the main shoot terminal node at an interval of 30 days, starting from 30 DAS. The plant height was measured in centimetre.

2.1.2 Leaf area index

For leaf area measurement, leaf area of selected sampled plants in each treatment was measured using leaf area meter. The leaf area index was expressed as the ratio of total leaf area in relation with the total ground area per plant (Watson 1947).

$$\text{LAI} = \frac{\text{Leaf Area plant cm}^2}{\text{Ground Area plant cm}^2}$$

2.1.3 Number of branches

The mean number of primary branches per plant emerging from the main shoot was counted at 30, 60, 90 DAS and at harvest.

2.1.4 Dry matter production

From each gross plot, five representative plants were uprooted randomly, labelled and carefully stored in brown paper bags. Dry weights of the various plant components were recorded individually after the samples were dried, the samples were air dries for about a week and then oven dried at, 65°C oven.

2.2 Plant analysis

2.2.1. Nitrogen uptake (kg ha^{-1})

Nitrogen content in pod and haulm samples was estimated by employing modified Kjeldhal's method (Jackson, 1967) using automatic kelplus distillation unit. After digesting the plant sample in concentrated sulphuric acid and hydrogen peroxide (Piper, 1966), the plant samples were subjected to distillation and the nitrogen content was expressed in percentage. N uptake was determined by multiplying the dry mater production at harvest by respective percentage of N content in pod and haulm samples expressed in kg ha^{-1}.

$$\text{N uptake (kg ha}^{-1}) = \frac{\text{N content (\%) x dry matter (kg ha}^{-1})}{100}$$

2.2.2. Phosphorus uptake (kg ha^{-1})

Phosphorus uptake was estimated after digesting the plant and pod samples with diacid mixture with nitric acid and perchloric acid in 9:4 ratio. The extract thus obtained through digestion was diluted with distilled water and the volume was made up to 50 ml. The phosphorous content in the extract was determined using spectrophotometer (Shimadeu UV-1800 double beam spectrophotometer) at a wave length 420 nm by vanado-molybdo phosphate yellow colour method as described by Piper (1966) and the phosphorous content was expressed in percentage.

$$\text{P uptake (kg ha}^{-1}) = \frac{\text{P content (\%) x dry matter (kg ha}^{-1})}{100}$$

2.2.3. Potassium Uptake (kg ha^{-1})

Potassium content was estimated after digesting the plant and pod samples with diacid mixture with nitric acid and perchloric acid in 9:4 ratio. The extract thus obtained was diluted using distilled water and the volume should be made up to 50 ml. The uptake of potassium content in the extract was determined by using flame photometer (Elico CL 378) as described by Jackson (1967) and it was expressed in terms of percentage. The respective K uptake was calculated from pod and haulm samples using following formula and converted into kg ha^{-1}.

$$\text{K uptake (kg ha}^{-}) = \frac{\text{K content (\%) x dry matter (kg ha}^{-1})}{100}$$

2.2.4. Sulphur Uptake (kg ha^{-1})

Sulphur content in digested plant samples were estimated from diluted plant extract calorimetrically as described by Palaskar *et al.* (1981). It was calculated by using the following formula.

$$\text{S uptake (kg ha}^{-1}) = \frac{\text{S content (\%) x dry matter (kg ha}^{-1})}{100}$$

2.3. Pod yield

Pods from each net plot were dried to constant weight and expressed as pod yield in kg ha^{-1}.

3. Results and Discussion

3.1. Plant height (cm)

Plant height in groundnut is governed by both climatic factors and genetical characters. Data presented in Table 1. showed a progressive increase in plant height with crop age, reaching maximum at harvest. At 30 DAS, neither planting geometry nor varieties exhibited a significant effect on plant height (mean: 5.6 cm) and the interaction effect was also non-significant, indicating uniform early growth across treatments. However, at later stages (60 DAS, 90 DAS and harvest), planting geometry significantly influenced plant height. The closer spacing of 15:15 × 10 cm (P2) consistently recorded the highest plant height (11.1, 20.8, and 32.5 cm at 60 DAS, 90 DAS, and harvest, respectively), followed by 20:20 × 10 cm (P3). Wider spacings (25:25 × 10 cm (P4) and 30 × 10 cm (P1)) resulted in comparatively lower plant height, with both treatments remaining statistically on par. This trend suggests that closer spacing enhances vertical growth, likely due to better light interception, reduced lateral spread and more efficient nutrient utilization. These findings are in agreement with earlier reports by Aruna and Reddy (2019) [2] and Joshi *et al.* (2019) [12], who also observed greater plant height under narrower spacing. Varietal differences were non-significant at 30 DAS but became significant at later stages. Girnar 5 (V2) recorded the highest plant height at all advanced stages (11.1, 20.1, and 31.4 cm at 60 DAS, 90 DAS and harvest, respectively), and remained statistically on par with Girnar 4 (V1). K6 (V4) showed moderate performance, while Avtar (V3) consistently recorded the lowest plant height. These variations are primarily attributed to inherent genetic differences among the varieties. Similar variability in plant height among groundnut genotypes has been reported by Sujathamma and Naik (2022) and Bendu *et al.* (2022) [3]. The interaction between planting geometry and varieties was non-significant across all growth stages, indicating independent effects of these factors.

3.2. Leaf area index

The data (Table 2) revealed that LAI increased with crop growth and was significantly influenced by planting geometry and varieties, except at early stage. At 30 DAS, LAI (0.4–0.5) did not differ significantly among treatments, indicating uniform initial canopy development. However, from 60 DAS onwards, planting geometry had a pronounced effect. The spacing of 25:25 × 10 cm (P4) recorded the highest LAI (2.2, 3.5, and 2.2 at 60 DAS, 90 DAS, and harvest, respectively), followed by 20:20 × 10 cm (P3) and 30 × 10 cm (P1), while the lowest LAI was consistently observed under 15:15 × 10 cm (P2). This indicates that wider spacing enhances LAI due to reduced intra-plant competition, better light interception, and improved resource availability, promoting superior canopy development. These findings are in line with reports by Arif *et al.* (2016) [1] and Kathirvelan and Kalaiselvan (2007) [17]. Among the varieties, no significant differences were observed at 30 DAS. At later stages, Girnar 5 (V2) consistently recorded the highest LAI (2.2, 3.5, and 2.3 at 60 DAS, 90 DAS, and harvest, respectively) and remained on par with Girnar 4 (V1). K6 (V4) showed moderate performance, while Avtar recorded lower LAI values. These differences are attributed to inherent varietal characteristics, as also reported by Bhargavi *et al.* (2017) [4]. The interaction effect between planting geometry and varieties was non-significant, indicating that the response of LAI to spacing was independent across all varieties.

3.3. Number of branches plant^{-1}

The data (Table 3) indicated that the number of branches plant^{-1} increased with crop growth but was not significantly influenced by either planting geometry or varieties and their interaction. Across all plant geometries, the number of branches remained uniform—about 6.0 at 60 DAS and 8.0 at 90 DAS and harvest—indicating that spacing had no measurable effect on branching pattern. This suggests that groundnut maintains a stable branching habit irrespective of plant density. Similar findings were reported by Sudhalakshmi *et al.* (2021) [26], Kathirvelan and Kalaiselvan (2007) [17] and Chaudhari *et al.* (2018) [7]. Among the varieties, no significant differences were observed at any growth stage. Branch numbers ranged from 3.9–4.0 at 30 DAS, 6.0–6.2 at 60 DAS, and 8.0–8.2 at 90 DAS and harvest. Although Girnar 5 (V2) showed a marginally higher number of branches, the variation was not statistically significant. These results are in agreement with Yilmaz and Jordan (2022) [29], who also reported no significant varietal effect on branching. The interaction between planting geometry and varieties was found to be non-significant.

3.4. Dry matter production (kg ha^{-1})

The data (Table 4) concluded that dry matter production increased progressively with crop growth and was significantly influenced by planting geometry and varieties, except at early stage. At 30 DAS (515–549 kg ha^{-1}), differences among plant geometries were non-significant, indicating uniform initial growth. However, from 60 DAS the spacing of 25:25 × 10 cm (P4) consistently recorded the highest dry matter production (2192, 4611, and 5211 kg ha^{-1} at 60 DAS, 90 DAS and harvest, respectively), followed by 20:20 × 10 cm (P3) and 30 × 10 cm (P1), while the lowest was observed in 15:15 × 10 cm (P1). This suggests that optimum spacing enhances canopy development, light interception and resource use efficiency, thereby promoting higher biomass accumulation. These findings are in agreement with Sawargaonkar *et al.* (2026) [24], Kumawat and Yadav (2011) [19] and Kumar *et al.* (2022) [18]. Among the varieties, no significant differences were observed at 30 DAS. At later stages, Girnar 5 (V2) recorded the highest dry matter production (2163, 4549, and 5181 kg ha^{-1} at 60 DAS, 90 DAS, and harvest, respectively) and remained on par with Girnar 4 (V1). K6 (V4) showed moderate performance, while Avtar consistently recorded the lowest values. These differences are mainly attributed to inherent varietal potential, as also reported by Priya *et al.* (2016) [21]. The interaction effect between planting geometry and varieties was non-significant, indicating independent effects of both factors.

3.5. N, P, K and S uptake in plant at flowering and at harvest

The data pertaining to nutrient uptake of N, P, K and S in plant at flowering and at harvest (both pod and haulm) as influenced by planting geometry and varieties was presented in the (Table 5).

Nitrogen

Among all plant geometries tested, the 25:25 × 10 cm (P4) planting geometry recorded significantly higher nutrient uptake at flowering (74.97 kg ha^{-1}) and at harvesting stage (158.5 kg ha^{-1}) (both pod and haulm) compared to other plant geometries. Among the varieties, Girnar 5 (V2) recorded maximum N uptake at flowering (73.97 kg ha^{-1}) and at harvesting stages (161.88 kg ha^{-1}) and it was statistically on par with Girnar 4 (V1).

Phosphorus

Higher phosphorus uptake was noticed in the spacing of 25:25 × 10 cm (P4) at both flowering (4.65 kg ha^{-1}) and harvesting stages (12.41 kg ha^{-1}) which was compared to the other spacings. Among the varieties studied, maximum phosphorus uptake was observed in Girnar 5 (V2) at flowering (4.48 kg ha^{-1}) and at harvesting stages (12.58 kg ha^{-1}) and it was on par with Girnar 4 (V1).

Potassium

25:25 × 10 cm (P4) planting geometry recorded higher amounts of phosphorus uptake as compared to the other treatments at flowering (18.15 kg ha^{-1}) and at harvesting stage (37.78 kg ha^{-1}). Girnar 5 (V2) variety consists of higher amounts of potassium uptake at flowering (17.34 kg ha^{-1}) and at harvesting stage (38.08 kg ha^{-1}) and it was on par with Girnar 4 (V1).

Sulphur

Higher amounts of sulphur uptake were observed in the spacing of 25:25 × 10 cm (P4) at flowering (4.02 kg ha^{-1}) and at harvesting stage (9.98 kg ha^{-1}) as compared to the other planting geometries. Among the varieties studied, Girnar 5 (V2) recorded maximum nutrient uptake at flowering (3.97 kg ha^{-1}) and harvesting stage (9.89 kg ha^{-1}) and it was on par with Girnar 4 (V1).

Higher nutrient uptake was recorded at 25:25 × 10 cm (P4) spacing, likely due to improved root development and efficient nutrient absorption. In contrast, 15:15 × 10 cm (P2) spacing showed comparatively lower uptake. Closer spacing within paired rows promotes root proliferation, enabling plants to explore a larger soil volume for water and nutrients. These results are in line with findings of Kamdi *et al.* (2012) [14], Chakraborty *et al.* (2020) and Chandolia *et al.* (2010) [6]. Girnar 5 (V2) recorded higher N, P, K, and S uptake, remaining on par with Girnar 4 (V1) and significantly superior to Avtar (V3) and K6 (V4) at both flowering and harvesting stages (pod and haulm). However, K6 (V4) showed higher nutrient uptake in haulm due to greater dry matter production. These findings agree with Kamdi *et al.* (2024) [16] and Mane *et al.* (2010) [20], indicating varietal differences in nutrient uptake and their importance in nutrient management. Interaction effect of planting geometry and varieties on nutrient uptake was found to be non-significant.

3.6. Pod yield (kg ha^{-1})

The data (Table 6) revealed that pod yield was significantly influenced by both planting geometry and varieties. Among the different plant geometries, 25:25 × 10 cm (P4) recorded the highest pod yield (1792 kg ha^{-1}), followed by 20:20 × 10 cm (P3) with 1581 kg ha^{-1}. These spacings resulted in yield increases of 58.4% and 39.8%, respectively, over the closer spacing of 15:15 × 10 cm (P2), which produced the lowest yield (1130 kg ha^{-1}). The superior performance of wider spacing may be attributed to reduced intra-plant competition for light, nutrients, and moisture, leading to better growth and pod development. These findings are in agreement with Chaudhari *et al.* (2018) [7], who also reported higher pod yield at an optimum spacing (22.5 × 10 cm) and Sawargaonkar *et al.* 2026) [24], emphasizing the importance of proper planting geometry in maximizing productivity. Groundnut varieties also showed a significant influence on pod yield. Girnar 5 (V2) recorded the highest yield (1759 kg ha^{-1}) and was statistically on par with Girnar 4 (V1) (1643 kg ha^{-1}). Both varieties significantly outperformed Avtar (V3) and K6 (V4), which recorded lower yields of 1352 kg ha^{-1} and 1113 kg ha^{-1}, respectively. The higher yield observed in Girnar varieties may be due to their superior genetic potential, better partitioning of assimilates and efficient utilization of available resources for pod formation. These results are consistent with the findings of Priya *et al.* (2015) [21], Gawas *et al.*, and Jaiswal (2017) [9, 11], who also reported significant varietal differences in pod yield. Overall, the study highlights that both optimum plant spacing and the selection of high-yielding varieties play a crucial role in enhancing groundnut productivity.

Table 1: Plant height as influenced by plant geometry and varieties of groundnut during *rabi* 2022-23

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Plant geometry (cm)				
P1: 30 × 10	5.6	9.5	16.7	26.2
P2: 15:15 × 10	5.6	11.1	20.8	32.5
P3: 20:20 × 10	5.6	10.3	18.7	29.6
P4: 25:25 × 10	5.5	9.2	16.0	25.9
S.Em±	0.07	0.24	0.50	0.61
CD (P=0.05)	NS	0.70	1.44	1.76
Varieties				
V1: Girnar 4	5.6	10.6	18.9	29.8
V2: Girnar 5	5.5	11.1	20.1	31.4
V3: Avtar	5.6	8.8	15.7	25.6
V4: K6	5.6	9.7	17.3	27.5
S.Em±	0.07	0.24	0.50	0.61
CD (P=0.05)	NS	0.70	1.44	1.76
Interaction (Plant geometry × Varieties)				
S.Em±	0.14	0.48	0.99	1.22
CD (P=0.05)	NS	NS	NS	NS

Table 2: Leaf area index as influenced by plant geometry and varieties of groundnut during *rabi* 2022-23

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Plant geometry (cm)				
P1: 30 × 10	0.4	1.8	3.0	1.8
P2: 15:15 × 10	0.5	1.6	2.8	1.5
P3: 20:20 × 10	0.5	2.0	3.2	2.0
P4: 25:25 × 10	0.5	2.2	3.5	2.2
S.Em±	0.04	0.05	0.05	0.05
CD (P=0.05)	NS	0.15	0.14	0.13
Varieties				
V1: Girnar 4	0.5	2.1	3.4	2.2
V2: Girnar 5	0.5	2.2	3.5	2.3
V3: Avtar	0.5	1.6	2.9	1.8
V4: K6	0.5	1.9	3.1	1.4
S.Em±	0.04	0.05	0.05	0.05
CD (P=0.05)	NS	0.15	0.14	0.13
Interaction (Plant geometry × Varieties)				
S.Em±	0.08	0.09	0.10	0.09
CD (P=0.05)	NS	NS	NS	NS

Table 3: Number of branches plant^{-1} of groundnut as influenced by plant geometry and varieties during *rabi* 2022-23

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Plant geometry (cm)				
P1: 30 × 10	4.0	6.0	8.0	8.0
P2: 15:15 × 10	4.0	6.0	8.0	8.0
P3: 20:20 × 10	4.0	6.1	8.1	8.1
P4: 25:25 × 10	4.0	6.2	8.2	8.2
S.Em±	0.06	0.07	0.12	0.12
CD (P=0.05)	NS	NS	NS	NS
Varieties				
V1: Girnar 4	4.0	6.0	8.1	8.1
V2: Girnar 5	4.0	6.2	8.2	8.2
V3: Avtar	3.9	6.0	8.0	8.0
V4: K6	4.0	6.0	8.1	8.1
S.Em±	0.06	0.07	0.12	0.12
CD (P=0.05)	NS	NS	NS	NS
Interaction (Plant geometry × Varieties)				
S.Em±	0.12	0.14	0.24	0.24
CD (P=0.05)	NS	NS	NS	NS

Table 4: Dry matter production (kg ha^{-1}) of groundnut as influenced by plant geometry and varieties during *rabi* 2022-23

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Plant geometry (cm)				
P1: 30 × 10	518	1901	3596	4125
P2: 15:15 × 10	515	1734	2997	3622
P3: 20:20 × 10	530	2047	4160	4644
P4: 25:25 × 10	549	2192	4611	5211
S.Em±	10.60	47.25	107.05	121.93
CD (P=0.05)	NS	136.48	309.18	352.17
Varieties				
V1: Girnar 4	527	2098	4311	4841
V2: Girnar 5	538	2163	4549	5181
V3: Avtar	513	1704	3091	3713
V4: K6	534	1910	3410	3867
S.Em±	10.60	47.25	107.05	121.93
CD (P=0.05)	NS	136.48	309.18	352.17
Interaction (Plant geometry × Varieties)				
S.Em±	21.21	94.51	214.10	243.87
CD (P=0.05)	NS	NS	NS	NS

Table 5: Nitrogen, phosphorus, potassium and sulphur uptake (kg ha^{-1}) of groundnut varieties as influenced by planting geometries at flowering stage

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	S uptake (kg ha^{-1})
Plant geometry (cm)				
P1: 30 × 10	64.68	3.79	15.37	3.46
P2: 15:15 × 10	57.48	3.35	12.94	3.13
P3: 20:20 × 10	69.66	4.18	16.72	3.74
P4: 25:25 × 10	74.97	4.65	18.15	4.02
SEm ±	1.55	0.12	0.41	0.09
CD (P=0.05)	4.46	0.36	1.20	0.27
Varieties				
V1: Girnar 4	71.20	4.23	16.43	3.77
V2: Girnar 5	73.97	4.48	17.34	3.97
V3: Avtar	56.78	3.49	14.33	3.16
V4: K6	64.85	3.76	15.10	3.45
SEm ±	1.55	0.12	0.41	0.09
CD (P=0.05)	4.46	0.36	1.20	0.27
Interaction P × V				
SEm ±	3.09	0.25	0.83	0.19
CD (P=0.05)	NS	NS	NS	NS

Table 6: Nitrogen and phosphorus uptake (kg ha^{-1}) of groundnut varieties as influenced by planting geometries at harvest

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Pod	Haulm	Total	Pod	Haulm	Total
Plant geometry (cm)						
P1: 30 × 10	45.50	83.43	128.93	5.53	4.52	10.05
P2: 15:15 × 10	35.88	73.75	109.63	4.50	3.94	8.44
P3: 20:20 × 10	49.72	93.13	142.85	6.03	5.20	11.23
P4: 25:25 × 10	54.91	103.59	158.5	6.60	5.81	12.41
S.Em±	1.12	3.34	4.46	0.18	0.20	0.38
CD (P=0.05)	3.24	9.63	12.87	0.52	0.57	1.09
Varieties						
V1: Girnar 4	52.22	97.34	149.56	6.45	5.27	11.72
V2: Girnar 5	56.23	105.65	161.88	6.87	5.71	12.58
V3: Avtar	42.74	69.47	112.21	5.12	3.91	9.03
V4: K6	34.81	81.44	116.25	4.21	4.59	8.8
S.Em±	1.12	3.34	4.46	0.18	0.20	0.38
CD (P=0.05)	3.24	9.63	12.87	0.52	0.57	1.09
Interaction P × V						
S.Em±	2.25	6.68	8.92	0.36	0.39	0.76
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 7: Potassium and sulphur uptake (kg ha^{-1}) of groundnut varieties as influenced by planting geometries at harvest

Treatments	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Pod	Haulm	Total	Pod	Haulm	Total
Plant geometry (cm)						
P1: 30 × 10	9.19	22.32	31.51	2.74	5.01	7.75
P2: 15:15 × 10	7.42	19.82	27.24	2.31	4.43	6.74
P3: 20:20 × 10	10.11	24.19	34.3	3.26	5.67	8.93
P4: 25:25 × 10	10.95	26.83	37.78	3.70	6.28	9.98
S.Em±	0.29	0.85	1.14	0.10	0.19	0.29
CD (P=0.05)	0.83	2.46	3.29	0.28	0.56	0.84
Varieties						
V1: Girnar 4	10.71	25.64	36.35	3.37	5.80	9.17
V2: Girnar 5	11.24	26.84	38.08	3.62	6.27	9.89
V3: Avtar	8.68	18.86	27.54	2.76	4.32	7.08
V4: K6	7.05	21.82	28.87	2.29	5.00	7.29
S.Em±	0.29	0.85	1.14	0.10	0.19	0.29
CD (P=0.05)	0.83	2.46	3.29	0.28	0.56	0.84
Interaction P × V						
S.Em±	0.57	1.70	2.28	0.20	0.39	2.59
CD (P=0.05)	NS	NS	NS	NS	NS	NS

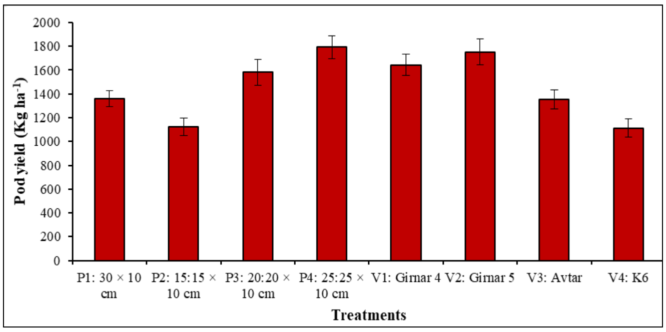

Fig 2: Pod yield (kg ha^{-1}) as influenced by planting geometries and varieties on broad bed and furrows

Conclusion

This study presents the results on growth, yield and nutrient uptake of groundnut (*Arachis hypogaea* L.) under different planting geometries on broad bed and furrow (BBF) during *rabi* season 2022-23 in the semi-arid region. The planting geometry of 25:25 × 10 cm resulted in higher dry matter production, nutrient uptake and pod yield. In contrast, closer spacing of 15:15 × 10 cm negatively affected yield due to increased competition among plants. However, plant height was higher under closer spacing, while the number of branches plant^{-1} remained unaffected by different planting geometries. Varietal differences significantly influenced growth, yield and nutrient uptake. Girnar 5 recorded superior performance and was found to be on par with Girnar 4, whereas Avtar and K6 showed comparatively lower performance. The interaction effect between planting geometry and varieties was found to be non-significant. Overall, the results emphasize that optimum spacing of 25:25 × 10 cm along with suitable varieties like Girnar 5 or Girnar 4 can enhance groundnut productivity under BBF system in semi-arid conditions.

References

1. Arif M, Bhunia SR, Verma IM, Khinchi V. Effect of crop geometry and drip irrigation on growth, yield and economics of groundnut (*Arachis hypogaea* L.). Environment and Ecology. 2016;34(4):2274-2278.
2. Aruna E, Reddy APK. Effect of crop geometry on growth, yield and economics of rabi groundnut. Journal of Experimental Biology and Agricultural Sciences. 2019;7(5):477-480.
3. Bendu JM, Mansaray A, Bah AM, Momoh EJJ. Effect of planting method and spacing on the growth parameters of three Bambara groundnut cultivars in two agro-climatic zones of Sierra Leone. 2022.
4. Bhargavi H, Reddy MS, Reddy UVB. Evaluation of influence of varieties and plant densities on growth and yield parameters of groundnut under irrigated conditions. Trends in Biosciences. 2017;10(33):7091-7093.
5. Chakraborthy M, Martin Luther M, PR C, SR C. Response of groundnut (*Arachis hypogaea* L.) to nitrogen levels and plant geometry. The Andhra Agricultural Journal. 2019;66(4):606-609.
6. Chandolia PC, Dadheech RC, Solanki NS, Mundra SL. Weed management in groundnut (*Arachis hypogaea* L.) under varying crop geometry. 2010.
7. Chaudhari PG, Chaudhari PP, Chaudhari MK. Response of summer groundnut (*Arachis hypogaea* L.) to date of sowing and spacings. International Journal of Chemical Studies. 2018;6(2):1504-1506.
8. FAOSTAT. Food and agriculture data. 2019.
9. Gawas D, Mane AV, Burondkar MM, Kanase T, Kasture MC, Dalavi VV. Yield performance of groundnut (*Arachis hypogaea* L.) genotypes under varying plant densities and seasons. International Journal of Chemical Studies. 2020;8(6):2383-2387.
10. Groundnut outlook report January to May 2021. 2021.
11. Jaiswal AB, Gourkhede PH. Assessment of groundnut (*Arachis hypogaea* L.) genotypes for plant geometry during kharif season. International Journal of Communication System. 2017;5(6):1522-1527.
12. Joshi E, Sasode DS, Sikarwar RS, Gupta V, Kasana BS. Optimizing crop geometry and nutrient management for yield, water productivity and economics of kharif groundnut (*Arachis hypogaea* L.). Legume Research. 2019;42(5):676-679.
13. Kamble AS, Waghmode BD, Sagvekar VV, Navhale VC, Mahadkar UV. Effect of land configuration and mulching on productivity and energy use in groundnut (*Arachis hypogaea*). Indian Journal of Agronomy. 2016;61(4):489-494.
14. Kamdi PJ, Sethi HN. Effect of different fertilizer levels on uptake and availability of nutrients in sweet sorghum. Green Farming. 2012;3(2):171-173.
15. Kamdi PJ, Swain DK, Wani SP. Developing climate change

agro-adaptation strategies through field experiments and simulation analyses for sustainable sorghum production in semi-arid tropics of India. Agricultural Water Management. 2023;286:108399.
16. Kamdi PJ, Swain DK, Wani SP. Improving grain quality and nitrogen use efficiency of cereal-based cropping systems on vertisols in semi-arid tropics. Field Crops Research. 2024;307:109258.
17. Kathirvelan P, Kalaiselvan P. Studies on agro management techniques for confectionery groundnut under irrigated condition. Research Journal of Agriculture and Biological Sciences. 2007;3(1):52-58.
18. Kumar B, Umesha C. Influence of zinc and spacing on growth and yield traits of groundnut (*Arachis hypogaea* L.). International Journal of Plant and Soil Science. 2022;34(15):79-83.
19. Kumawat BMS, Yadav R. Effect of planting geometry and nitrogen management on groundnut (*Arachis hypogaea*) in loamy sand soil of Rajasthan. Indian Journal of Agricultural Sciences. 2011;81(1):86-88.
20. Mane BN, Mhaskar NV, Patil BP. Effect of sowing time, variety and mulching on NPK uptake and pod yield of groundnut under lateritic soil of Konkan region. Journal of Soils and Crops. 2010;20(1):52-57.
21. Priya TB, Subramanyam D, Sumathi V. Performance of groundnut (*Arachis hypogaea* L.) cultivars under different plant populations during early kharif. Indian Journal of Agricultural Research. 2016;50(4):362-365.
22. Sawargaonkar G, Pasumarthi R, Kale S, Choudhari P, Rakesh S, Mutnuri S, *et al*. Valorization of peanut shells through biochar production using slow and fast pyrolysis and its detailed physicochemical characterization. Frontiers in Sustainability. 2024;5:1417207.
23. Sawargaonkar GL, Davala MS, Rakesh S, Kamdi PJ, Khopade RY, Nune R, *et al*. Envirotyping helps in better understanding the root cause of success and limitations of rainfed production systems. Frontiers in Environmental Science. 2024;12:1417199.
24. Sawargaonkar GL, Kamdi PJ, Kale S, Garg KK, Singh R, Roul PK, *et al*. Genotype × cropping system × management interactions: Long-term research and system modelling in transplanted pigeonpea. Journal of Agriculture and Food Research. 2026;102820.
25. Sawargaonkar GL, Kamdi PJ, Kale S, Shinde S, Das SS, Kausadikar H, *et al*. Leveraging genotype × management synergies to enhance pigeonpea productivity, profitability, and sustainability in semi-arid tropics. Frontiers in Agronomy. 2025;7:1590421.
26. Sudhalakshmi C, Gopalakrishnan M, Rani S. Optimization of fertilizer doses and plant population in summer irrigated groundnut (*Arachis hypogaea*). Journal of Pharmacognosy and Phytochemistry. 2021;10(1):1866-1869.
27. Sujatamma P, Naik BSK. Response of groundnut varieties to different seed rates. The Pharma Innovation Journal. 2022;11(4):956-959.
28. Vekariya PD, Sanepara DP, Limbasia BB, Sharma GR, Akbari KN. Effect of different size of broad bed and furrow on runoff and soil loss and productivity of groundnut (*Arachis hypogaea* L.) under rainfed conditions. International Journal of Bio-resource and Stress Management. 2015;6:316-321.
29. Yilmaz M, Jordan DL. Effect of plant density on yield and quality of peanut (*Arachis hypogaea* L.) cultivars. Turkish Journal of Field Crops. 2022;27(2):217-223.