The Pharma Innovation Journal 2022; 11(12): 5830-5836

www.ThePharmaJournal.com

The Pharma Innovation

**ISSN (E): 2277-7695**
**ISSN (P): 2349-8242**
**NAAS Rating: 5.23**
TPI 2022; 11(12): 5830-5836

www.thepharmajournal.com
Received: 09-09-2022
Accepted: 13-10-2022

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# Studies on possibility of increasing the translocation of assimilates to kernel development by foliar application of growth regulators and micronutrients

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**Abstract**
A field Studies on chemical regulation of translocation of assimilates in groundnut, *Arachis hypogaea* L. cv. Phule Unnati and KDG-160 through PGRs and micronutrients was conducted at the PGI, MPKV, Rahuri during summer season of 2018-2019. In the present investigation, among the PGR's, GA- 50 ppm was found to be the most effective than BA- 10 ppm treatments. While among the micronutrients Mo-0.014 mM, B-0.015 mM and Ca-0.10 mM were found more effective for increasing the morpho-physiological characters. The foliar application of PGR's and MNR's and their combinations were found to be superior for increasing the translocation of assimilates towards the kernel development, dry matter production and its efficient partitioning, various morpho-physiological characters and growth functions.

**Keywords:** Gibberellic acid, PGR's, Phule Unnati, KDG-160 and MNR's

## Introduction

The cultivated groundnut, *Arachis hypogaea* L. originated from South America. The term *Arachis* is derived from the Greek word "arachos", meaning a weed and "*hypogaea*", meaning underground chamber, *i.e.*, in botanical terms, a weed with fruits produced below the soil surface. Groundnut can be grown in a wide range of temperate and humid regions, but numerically higher production comes from the semiarid tropics. Optimum temperature ranges between 20 and 30 °C; productivity is limited below 16 °C and above 32 °C. The thermal time requirement for groundnut depends upon cultivar and ranges from 1800 to 2400 degree-days (at a base temperature of 10 °C) or heat units. Groundnuts are affected by day length and light intensity (Anon, 2021) [1-2]. The crop prefers clear days with lots of sunlight for optimum production. It is a day-neutral plant with the flowering time controlled by temperature. However, photoperiod plays an important role in reproductive efficiency (flowers producing pegs and pods) and assimilate distribution during the post-flowering period. Long days promote vegetative growth at the expense of reproductive growth. The sizable production alone is not enough to boost the export of hand-picked selections (HPS) groundnut but it must be coupled with quality which is most important for increasing the demand and also fetching more prices in the world market (Anon, 2021) [1-2]. Low aflatoxin, low oil content and high sugar in the kernel are the three important parameters of better quality of HPS groundnut.

## Materials and Methods

The seed of groundnut varieties Phule Unnati and KDG 160 was sown at distance of 30 cm in between row and 10 cm in between plants on 16$^{th}$ February, 2018 and 4$^{th}$ February 2019, in the flat beds by dibbling method at the rate of 150 and 100 kg per ha, respectively. The stock solutions of GA and BA were prepared in the laboratory after taking into consideration their a.i. by dissolving in absolute ethyl alcohol *i.e.*, 20-30 ml and Calcium sulphate, Sodium tetraborate, Ammonium molybdate, Zinc sulphate and Ferrous sulphate were directly dissolved in distilled water as per required concentrations. The prepared stock solutions of plant growth regulators and micronutrients were used by making dilutions of required concentrations at the time of foliar application. The foliar sprays of plant hormones and micronutrients were given at 30 and 45 days after sowing and absolute control and the plots under water spray with all necessary precaution were taken. The observations were recorded for comparison of other treatments with absolute control and water spray. The recommended Agronomic practices (Gap filling @ 8 DAS, Thinning, @ 15DAS, Weeding and Irrigation) and plant protection measures were adopted during crop growth.

Three plants from each treatment were taken at each sampling and their leaves were separated and the leaf area of green leaves was measured with the help of an Automatic leaf area meter (Model AAM-7) and expressed in $dm^2$ per plant. Three plants from each treatment were taken at each sampling, their leaves were separated and the leaf area of green leaves was determined with the help of an Automatic leaf area meter and LAI was calculated by the formula given by Watson (1947) [11]. Leaf area duration was calculated by the following formula suggested by and expressed in days. The total numbers of flowers were recorded for all the treatments.

## Results and Discussion

The observations on different morpho-physiological characters such as leaf area, leaf area index, leaf area duration, number of flowers per plant are described below.

### 1. Leaf area ($dm^2$) per plant

The data on the leaf area (LA) as influenced by varieties were non-significant however it was significant due to treatments and interactions which are presented in Tables 1 and 2 during 2017-2018, 2018-2019 and pooled. Among both the varieties Phule Unnati showed numerically higher leaf area (6.86, 7.41, 7.13 $dm^2$) whereas, KDG 160 showed (6.71, 7.41, 7.06 $dm^2$). Among all treatments irrespective of the varieties, numerically higher leaf area (7.39, 7.96, 7.68 $dm^2$) was observed under $T_1$ (GA 50 ppm) which was at par with $T_9$ (GA-50 ppm + Mo-0.014 mM) and $T_3$ (Mo-0.014 mM) and the minimum leaf area per plant (4.75, 4.91, 4.83 $dm^2$) was observed under $T_{12}$ (Control). The interaction effect of different sprays and varieties on the leaf area per plant was found numerically higher under $V_1T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (7.42, 8.19, 7.81 $dm^2$) and in $V_2T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (7.42, 8.08, 7.03 $dm^2$) which was at par with $V_1T_1$ (GA 50 ppm), $V_2T_1$ (GA 50 ppm) and $V_1T_3$ (Mo-0.014 mM), $V_2T_3$ (Mo-0.014 mM) and the minimum leaf area per plant (5.35, 5.31, 5.33 $dm^2$) was found in $V_1T_{12}$ (Control) and (4.15, 4.51 and 4.33 $dm^2$) in $V_2T_{12}$ (Control). The results of the present findings are more or less in agreement with Geethanjali *et al.* (2015) [6], who reported that the leaf area was influenced by the foliar application of PGR's and boron at 25 and 45 DAS. Similarly, Faldu *et al.* (2018) [5] reported influence of plant growth regulators on morphological and physiological parameters of groundnut, *Arachis hypogaea* L. cv. GJG-9 and stated that foliar application of $GA_3$ (50, 100 ppm) at 40 & 55 DAS increased no. of leaves. Solanke *et al.* (2018) [8] also reported that, the foliar application of growth regulators *viz*., $GA_3$, IAA, CCC, TIBA and MH at flowering stage (35 DAS) and pod initiation stage (50 DAS) would be promising practice for increasing growth factors such as leaf area in soya bean.

**Table 1:** Effect of different sprays on leaf area ($dm^2$) per plant at

| | Variety (V) | Leaf area ($dm^2$) per plant | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1$ | Phule Unnati | 6.86 | 7.41 | 7.13 |
| $V_2$ | KDG-160 | 6.71 | 7.41 | 7.06 |
| | SEm.± | 0.09 | 0.08 | 0.10 |
| | CD at 5% | NS | NS | NS |
| **Treatment (T)** | | | | |
| $T_1$ | GA-50 ppm | 7.39 | 7.96 | 7.68 |
| $T_2$ | Ca-0.10 Mm | 6.77 | 7.40 | 7.09 |
| $T_3$ | Mo-0.014 mM | 7.08 | 7.66 | 7.43 |
| $T_4$ | $ZnSO_4$ -0.5% | 6.78 | 7.43 | 7.10 |
| $T_5$ | $FeSO_4$ -0.5% | 6.78 | 7.42 | 7.10 |
| $T_6$ | BA-10 ppm | 6.81 | 7.40 | 7.10 |
| $T_7$ | B-0.015 mM | 6.82 | 7.47 | 7.15 |
| $T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 7.05 | 7.42 | 7.21 |
| $T_9$ | GA-50 ppm + Mo - 0.014 Mm | 7.30 | 7.74 | 7.57 |
| $T_{10}$ | BA-10 ppm + $ZnSO_4$ - 0.5% | 7.04 | 7.23 | 7.13 |
| $T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 6.80 | 7.50 | 7.15 |
| $T_{12}$ | Control | 4.75 | 4.91 | 4.83 |
| | SEm. (±) | 0.22 | 0.20 | 0.26 |
| | CD at 5% | 0.63 | 0.56 | 0.72 |

**Table 2:** Interaction effect of varieties and treatments on leaf area ($dm^2$) per plant

| | Interaction | Leaf area ($dm^2$) per plant | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1T_1$ | GA-50 ppm | 7.41 | 7.94 | 7.67 |
| $V_1T_2$ | Ca-0.10 Mm | 6.80 | 7.33 | 7.06 |
| $V_1T_3$ | Mo-0.014 mM | 7.01 | 7.53 | 7.27 |
| $V_1T_4$ | $ZnSO_4$ -0.5% | 6.80 | 7.33 | 7.06 |
| $V_1T_5$ | $FeSO_4$ -0.5% | 6.81 | 7.34 | 7.07 |
| $V_1T_6$ | BA-10 ppm | 6.86 | 7.38 | 7.12 |
| $V_1T_7$ | B-0.015 mM | 6.83 | 7.42 | 7.13 |
| $V_1T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 7.00 | 7.12 | 7.14 |
| $V_1T_9$ | GA-50 ppm + Mo-0.014 Mm | 7.42 | 8.19 | 7.81 |
| $V_1T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 7.00 | 7.15 | 7.14 |
| $V_1T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 6.90 | 7.18 | 7.19 |

| | | | | |
|---|---|---|---|---|
| $V_1T_{12}$ | Control | 5.35 | 5.31 | 5.33 |
| $V_2T_1$ | GA-50 ppm | 7.37 | 7.98 | 7.68 |
| $V_2T_2$ | Ca-0.10 Mm | 7.01 | 7.78 | 7.39 |
| $V_2T_3$ | Mo-0.014 mM | 7.23 | 7.68 | 7.41 |
| $V_2T_4$ | $ZnSO_4$ -0.5% | 6.76 | 7.52 | 7.14 |
| $V_2T_5$ | $FeSO_4$ -0.5% | 6.76 | 7.50 | 7.13 |
| $V_2T_6$ | BA-10 ppm | 6.76 | 7.41 | 7.09 |
| $V_2T_7$ | B-0.015 mM | 6.81 | 7.52 | 7.16 |
| $V_2T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 7.04 | 7.12 | 7.03 |
| $V_2T_9$ | GA-50 ppm + Mo-0.014 Mm | 7.42 | 8.08 | 7.73 |
| $V_2T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 7.06 | 7.08 | 7.03 |
| $V_2T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 6.71 | 7.52 | 7.11 |
| $V_2T_{12}$ | Control | 4.15 | 4.51 | 4.33 |
| | SEm. (±) | 0.31 | 0.28 | 0.36 |
| | CD at 5% | NS | NS | NS |
| **Treated v per s control** | | | | |
| $V_1$ | Treated | 6.99 | 7.60 | 7.30 |
| $V_1$ | Control | 5.35 | 5.31 | 5.33 |
| $V_2$ | Treated | 6.64 | 7.47 | 7.11 |
| $V_2$ | Control | 4.15 | 4.51 | 4.33 |
| | SEm. (±) | 0.23 | 0.20 | 0.26 |
| | CD at 5% | 0.65 | 0.58 | 0.75 |

**2. Leaf area index (LAI)**

The data on the leaf area index (LAI) as influenced by varieties, treatments and their interactions were non-significant which are presented in Tables 3 and 4 during 2017-2018, 2018-2019 and pooled. Among both the varieties Phule Unnati showed numerically higher leaf area index (1.47, 1.65, 1.56) whereas KDG 160 showed (1.40, 1.62, 1.51). Among all treatments irrespective of the varieties, numerically higher leaf area index (1.67, 1.90, 1.78) was observed under $T_1$ with GA 50 ppm which was at par with $T_9$ (GA-50 ppm + Mo-0.014 mM) and $T_3$ (Mo-0.014 mM) and the minimum leaf area index (1.15, 1.27, 1.21) was observed under $T_{12}$ (Control). The interaction effect of different sprays and varieties on the leaf area index was found numerically higher under $V_1T_9$ (GA-50 ppm + Mo-0.014 mM) *i.e.*, (1.65, 2.04, 1.85) and $V_2T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (1.62, 1.94, 1.78) and which was at par with $V_1T_1$ (GA 50 ppm), $V_2T_1$ (GA 50 ppm) and $V_1T_3$ (Mo-0.014 mM), $V_2T_3$ (Mo-0.014 mM) and the minimum leaf area index (1.09, 1.29, 1.19) was found in $V_1T_{12}$ (Control) and (1.21, 1.25, 1.23) in $V_2T_{12}$ (Control). The results of the present findings are in association with Behera *et al.* (2017) [4], who reported that the application of $GA_3$ (20, 10 ppm) and other PGR's at different concentration increased growth parameters such as leaf area, leaf are index and leaf area duration with irrespective of varieties in groundnut. Similarly, Geethanjali *et al.* (2015) [6] reported that growth characteristics *viz.*, leaf area, LAI and more retention of flowers were influenced by the foliar application of PGR's and boron at 25 and 45 DAS, due to increased translocation of sugars from source to sink. Faldu *et al.* (2018) [5] also reported, Influence of plant growth regulators on morphological and physiological parameters of groundnut (*Arachis hypogaea* L.) cv. GJG-9 and stated that foliar application of $GA_3$ (50, 100 ppm) at 40 & 55 DAS increased the plant height, no. of primary branches, no. of leaves and LAI.

**Table 3:** Effect of different sprays on leaf area index (LAI)

| | Variety (V) | Leaf area index (LAI) | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1$ | Phule Unnati | 1.47 | 1.65 | 1.56 |
| $V_2$ | KDG-160 | 1.40 | 1.62 | 1.51 |
| | SEm.± | 0.06 | 0.07 | 0.08 |
| | CD at 5% | NS | NS | NS |
| **Treatment (T)** | | | | |
| $T_1$ | GA-50 ppm | 1.67 | 1.90 | 1.78 |
| $T_2$ | Ca-0.10 Mm | 1.50 | 1.63 | 1.56 |
| $T_3$ | Mo-0.014 mM | 1.59 | 1.79 | 1.64 |
| $T_4$ | $ZnSO_4$ -0.5% | 1.16 | 1.30 | 1.23 |
| $T_5$ | $FeSO_4$ -0.5% | 1.17 | 1.33 | 1.25 |
| $T_6$ | BA-10 ppm | 1.42 | 1.59 | 1.50 |
| $T_7$ | B-0.015 mM | 1.46 | 1.66 | 1.56 |
| $T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 1.45 | 1.70 | 1.57 |
| $T_9$ | GA-50 ppm + Mo - 0.014 Mm | 1.64 | 1.81 | 1.62 |
| $T_{10}$ | BA-10 ppm + $ZnSO_4$ - 0.5% | 1.42 | 1.72 | 1.57 |
| $T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 1.56 | 1.63 | 1.44 |
| $T_{12}$ | Control | 1.15 | 1.27 | 1.21 |
| | SEm. (±) | 0.15 | 0.19 | 0.21 |
| | CD at 5% | NS | NS | NS |

**Table 4:** Interaction effect of varieties and treatments on leaf area index (LAI)

| | Interaction | Leaf area index (LAI) | | |
|---|---|---|---|---|
| | | **2017-18** | **2018-19** | **Pooled** |
| $V_1T_1$ | GA-50 ppm | 1.68 | 1.86 | 1.77 |
| $V_1T_2$ | Ca-0.10 Mm | 1.48 | 1.56 | 1.52 |
| $V_1T_3$ | Mo-0.014 mM | 1.62 | 1.81 | 1.72 |
| $V_1T_4$ | $ZnSO_4$ -0.5% | 1.19 | 1.37 | 1.28 |
| $V_1T_5$ | $FeSO_4$ -0.5% | 1.28 | 1.43 | 1.35 |
| $V_1T_6$ | BA-10 ppm | 1.46 | 1.61 | 1.54 |
| $V_1T_7$ | B-0.015 mM | 1.55 | 1.70 | 1.62 |
| $V_1T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 1.50 | 1.62 | 1.56 |
| $V_1T_9$ | GA-50 ppm + Mo-0.014 Mm | 1.65 | 2.04 | 1.85 |
| $V_1T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 1.47 | 1.72 | 1.59 |
| $V_1T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 1.61 | 1.76 | 1.69 |
| $V_1T_{12}$ | Control | 1.09 | 1.29 | 1.19 |
| $V_2T_1$ | GA-50 ppm | 1.65 | 1.84 | 1.70 |
| $V_2T_2$ | Ca-0.10 Mm | 1.51 | 1.70 | 1.61 |
| $V_2T_3$ | Mo-0.014 mM | 1.55 | 1.77 | 1.66 |
| $V_2T_4$ | $ZnSO_4$ -0.5% | 1.14 | 1.22 | 1.18 |
| $V_2T_5$ | $FeSO_4$ -0.5% | 1.05 | 1.24 | 1.15 |
| $V_2T_6$ | BA-10 ppm | 1.38 | 1.56 | 1.47 |
| $V_2T_7$ | B-0.015 mM | 1.37 | 1.62 | 1.50 |
| $V_2T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 1.39 | 1.67 | 1.58 |
| $V_2T_9$ | GA-50 ppm + Mo-0.014 Mm | 1.62 | 1.94 | 1.78 |
| $V_2T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 1.37 | 1.72 | 1.54 |
| $V_2T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 1.50 | 1.69 | 1.60 |
| $V_2T_{12}$ | Control | 1.21 | 1.25 | 1.23 |
| | SEm. (±) | 0.22 | 0.28 | 0.30 |
| | CD at 5% | NS | NS | NS |
| **Treated v per s control** | | | | |
| $V_1$ | Treated | 1.50 | 1.68 | 1.59 |
| $V_1$ | Control | 1.09 | 1.29 | 1.19 |
| $V_2$ | Treated | 1.41 | 1.65 | 1.53 |
| $V_2$ | Control | 1.21 | 1.25 | 1.23 |
| | SEm. (±) | 0.16 | 0.20 | 0.22 |
| | CD at 5% | NS | NS | NS |

## 3. Leaf area duration

The data on the leaf area duration (LAD) as influenced by varieties were significant which are presented in Tables 5 and 6 during 2017-2018, 2018-2019 and pooled. The varietal difference was non-significant. However, Phule Unnati showed significantly higher leaf area duration (61.38, 65.52, 63.45 days) whereas KDG 160 showed (60.60, 64.54, 62.57 days). Among all treatments irrespective of the varieties, significantly higher leaf area duration (70.49, 74.83, 72.66 days) was observed under $T_1$ with (GA 50 ppm) which was at par with $T_9$ (GA-50 ppm + Mo-0.014 mM) and $T_3$ (Mo-0.014 mM) and the minimum leaf area duration (37.93, 42.43, 40.18 days) was observed under $T_{12}$ (Control). The interaction effect of different sprays and varieties were non-significant in respect to LAD. However numerically higher values were observed under $V_1T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (76.79, 74.46, 75.12 days) followed by $V_2T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (72.71, 75.04, 74.88 days), $V_1T_1$ (GA 50 ppm), $V_2T_1$ (GA 50 ppm) and $V_1T_3$ (Mo-0.014 mM), $V_2T_3$ (Mo-0.014 mM). The minimum leaf area duration (38.74, 43.08, 40.91 days) was found in $V_1T_{12}$ (Control) and (37.11, 41.78, 39.45 days) in $V_2T_{12}$ (Control). The results of the present findings derive support from the findings of Rajitha *et al.* (2018) [12], who reported dry matter production and allocation in groundnut under drought and foliar nutrition with micronutrients and PGRs at harvest resulted significantly higher leaf area, leaf area index, leaf area duration, stem, leaf and pod dry weight and also total dry matter partitioning. Similarly, Geethanjali *et al.* (2015) [6] reported that growth characteristics *viz*., leaf area and LAI were influenced by the foliar application of PGR's and boron at 25 and 45 DAS. Behera *et al.* (2017) [4] also reported that the application of $GA_3$ (20, 10 ppm) and other PGR's at different concentration increased growth parameters such as leaf area, leaf are index and leaf area duration with irrespective of varieties in groundnut.

**Table 5:** Effect of different sprays on leaf area duration (LAD) (days)

| | Variety (V) | Leaf area duration (LAD) | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1$ | Phule Unnati | 61.38 | 65.52 | 63.45 |
| $V_2$ | KDG-160 | 60.60 | 64.54 | 62.57 |
| | SEm.± | 1.05 | 1.15 | 1.35 |
| | CD at 5% | 3.10 | 3.17 | 4.01 |
| **Treatment (T)** | | | | |
| $T_1$ | GA-50 ppm | 70.49 | 74.83 | 72.66 |
| $T_2$ | Ca-0.10 Mm | 65.51 | 69.51 | 67.51 |
| $T_3$ | Mo-0.014 mM | 65.75 | 70.08 | 68.92 |
| $T_4$ | $ZnSO_4$ -0.5% | 64.76 | 68.76 | 66.76 |
| $T_5$ | $FeSO_4$ -0.5% | 62.55 | 66.28 | 64.41 |
| $T_6$ | BA-10 ppm | 60.68 | 64.48 | 62.58 |
| $T_7$ | B-0.015 mM | 63.01 | 66.67 | 64.84 |
| $T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 60.92 | 65.42 | 63.17 |
| $T_9$ | GA-50 ppm + Mo - 0.014 Mm | 66.75 | 71.25 | 69.00 |
| $T_{10}$ | BA-10 ppm + $ZnSO_4$ - 0.5% | 62.10 | 65.63 | 63.86 |
| $T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 59.45 | 63.03 | 61.24 |
| $T_{12}$ | Control | 37.93 | 42.43 | 40.18 |
| | SEm. (±) | 2.57 | 2.83 | 3.31 |
| | CD at 5% | 7.32 | 8.05 | 9.30 |

**Table 6:** Interaction effect of varieties and treatments on leaf area duration (LAD) (days)

| | Interaction | Leaf area duration (LAD) | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1T_1$ | GA-50 ppm | 70.58 | 74.91 | 72.75 |
| $V_1T_2$ | Ca-0.10 Mm | 65.62 | 69.95 | 67.78 |
| $V_1T_3$ | Mo-0.014 mM | 67.90 | 70.57 | 71.24 |
| $V_1T_4$ | $ZnSO_4$ -0.5% | 64.78 | 69.11 | 66.94 |
| $V_1T_5$ | $FeSO_4$ -0.5% | 63.05 | 66.61 | 64.83 |
| $V_1T_6$ | BA-10 ppm | 61.65 | 65.65 | 63.65 |
| $V_1T_7$ | B-0.015 mM | 63.30 | 66.97 | 65.14 |
| $V_1T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 61.13 | 66.13 | 63.63 |
| $V_1T_9$ | GA-50 ppm + Mo-0.014 Mm | 76.79 | 74.46 | 75.12 |
| $V_1T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 63.13 | 66.53 | 64.83 |
| $V_1T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 59.85 | 63.32 | 61.58 |
| $V_1T_{12}$ | Control | 38.74 | 43.08 | 40.91 |
| $V_2T_1$ | GA-50 ppm | 70.41 | 74.74 | 72.57 |
| $V_2T_2$ | Ca-0.10 Mm | 65.41 | 69.07 | 67.24 |
| $V_2T_3$ | Mo-0.014 mM | 68.59 | 70.59 | 70.59 |
| $V_2T_4$ | $ZnSO_4$ -0.5% | 64.74 | 68.41 | 66.57 |
| $V_2T_5$ | $FeSO_4$ -0.5% | 62.04 | 65.94 | 63.99 |
| $V_2T_6$ | BA-10 ppm | 59.71 | 63.31 | 61.51 |
| $V_2T_7$ | B-0.015 mM | 62.71 | 66.37 | 64.54 |
| $V_2T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 60.70 | 64.70 | 62.70 |
| $V_2T_9$ | GA-50 ppm + Mo-0.014 Mm | 72.71 | 75.04 | 74.88 |
| $V_2T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 61.06 | 64.73 | 62.90 |
| $V_2T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 59.04 | 62.74 | 60.89 |
| $V_2T_{12}$ | Control | 37.11 | 41.78 | 39.45 |
| | SEm. (±) | 3.63 | 4.00 | 4.68 |
| | CD at 5% | NS | NS | NS |
| **Treated v per s control** | | | | |
| $V_1$ | Treated | 63.43 | 67.56 | 65.50 |
| $V_1$ | Control | 38.74 | 43.08 | 40.91 |
| $V_2$ | Treated | 62.74 | 66.61 | 64.67 |
| $V_2$ | Control | 37.11 | 41.78 | 39.45 |
| | SEm. (±) | 2.69 | 2.95 | 3.46 |
| | CD at 5% | 7.65 | 8.40 | 9.71 |

## Phenological observations

### 1. Total number of flowers per plant

The data on the total number of flowers per plant as influenced by varieties, treatments and their interactions were significant which are presented in Tables 7 and 8 during 2017-2018, 2018-2019 and pooled. Among both the varieties Phule Unnati showed significantly higher total number of flowers per plant (70.82, 71.71, 71.27) whereas KDG 160 showed (70.42, 71.47, 70.95). Among all treatments irrespective of the varieties, significantly higher total number of flowers per plant (73.55, 75.46, 77.00) was observed under $T_1$ with GA 50 ppm which was increased progressively with the increase with increase in the age of the crop and it was at par with $T_9$ (GA-50 ppm + Mo-0.014 mM) and $T_3$ (Mo-0.014 mM) and total number of flowers per plant (69.29, 68.11, 68.70) was observed under $T_{12}$ (Control). The interaction effect of different sprays and varieties on the total number of flowers per plant was found significantly higher under $V_1T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (74.22, 75.56, 76.89) and $V_2T_9$ (GA-50 ppm + Mo-0.014 mM) i.e., (70.95, 71.61, 71.28) which was at par with $V_1T_1$(GA 50 ppm), $V_2T_1$ (GA 50 ppm) and $V_1T_3$ (Mo-0.014 mM), $V_2T_3$ (Mo-0.014 mM) and the minimum total number of flowers per plant (65.44, 65.43, 65.43) was found in $V_1T_{12}$ (Control) and (66.13, 65.79, 65.96) in $V_2T_{12}$ (Control). The results of the present findings are more or less in agreement with Yakubu *et al.* (2012), who reported that varietal response and gibberellic acid concentrations on yield and yield traits of groundnut (*Arachis hypogaea* L.) under wet and dry condition in which the highest flowering was obtained at 100 mg l-1 levels of gibberellic acid. Similarly, Geethanjali *et al.* (2015) [6] reported that more retention of flowers was influenced by the foliar application of PGR's and boron at 25 and 45 DAS, which also improved the yield and yield attributes due to increased translocation of sugars from source to sink. Avinasha *et al.* (2019) [3] also reported the effect of PGR's and micronutrients that altered the flower production there by pod yield and improved the partitioning efficiency of the trans locating assimilates to the sink organs in groundnut. Kiruthika *et al.*, (2018) [7] also recorded synchronization of pod maturity in groundnut by using plant growth regulators and nutrients by arresting or reducing early and late formed flowers which in turn might improve the peg to pod ratio. Sowjanya *et al.* (2022) [9] reported the influence of plant growth regulators on flowering in groundnut (*Arachis hypogaea* L.) with different concentrations of $GA_3$ and NAA at different growth stages. Vinothini *et al.*, (2018) [10] also reported the flowering pattern in relation to seed filling and multiplication rate in groundnut through $GA_3$ and nutrient sprays.

**Table 7:** Effect of different spray on total number of flowers per plant

| | Variety (V) | Total number of flowers per plant | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1$ | Phule Unnati | 70.82 | 71.71 | 71.27 |
| $V_2$ | KDG-160 | 70.42 | 71.47 | 70.95 |
| | SEm.± | 0.026 | 0.040 | 0.042 |
| | CD at 5% | 0.124 | 0.134 | 0.145 |
| **Treatment (T)** | | | | |
| $T_1$ | GA-50 ppm | 73.55 | 75.46 | 77.00 |
| $T_2$ | Ca-0.10 Mm | 70.43 | 71.84 | 71.64 |
| $T_3$ | Mo-0.014 mM | 72.00 | 74.58 | 73.29 |
| $T_4$ | $ZnSO_4$ -0.5% | 70.31 | 73.06 | 72.00 |
| $T_5$ | $FeSO_4$ -0.5% | 71.00 | 72.69 | 72.04 |
| $T_6$ | BA-10 ppm | 69.96 | 69.80 | 69.38 |
| $T_7$ | B-0.015 mM | 69.43 | 70.76 | 70.10 |
| $T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 70.95 | 72.02 | 71.49 |
| $T_9$ | GA-50 ppm + Mo - 0.014 Mm | 71.09 | 73.08 | 72.08 |
| $T_{10}$ | BA-10 ppm + $ZnSO_4$ - 0.5% | 69.21 | 69.49 | 69.35 |
| $T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 69.45 | 71.25 | 70.35 |
| $T_{12}$ | Control | 69.29 | 68.11 | 68.70 |
| | SEm. (±) | 0.65 | 0.10 | 1.03 |
| | CD at 5% | 1.85 | 2.84 | 1.30 |

**Table 8:** Interaction effect of varieties and treatments on total number of flowers per plant

| | Interaction | Total number of flowers per plant | | |
|---|---|---|---|---|
| | | 2017-18 | 2018-19 | Pooled |
| $V_1T_1$ | GA-50 ppm | 72.37 | 73.53 | 72.95 |
| $V_1T_2$ | Ca-0.10 Mm | 71.59 | 72.08 | 71.83 |
| $V_1T_3$ | Mo-0.014 mM | 72.11 | 72.59 | 72.35 |
| $V_1T_4$ | $ZnSO_4$ -0.5% | 72.09 | 72.04 | 72.01 |
| $V_1T_5$ | $FeSO_4$ -0.5% | 72.01 | 70.24 | 72.08 |
| $V_1T_6$ | BA-10 ppm | 69.22 | 70.55 | 69.89 |
| $V_1T_7$ | B-0.015 mM | 69.11 | 71.78 | 70.44 |
| $V_1T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 71.00 | 72.47 | 71.73 |
| $V_1T_9$ | GA-50 ppm + Mo-0.014 Mm | 74.22 | 75.56 | 76.89 |
| $V_1T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 69.33 | 68.89 | 69.11 |
| $V_1T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 69.45 | 71.73 | 70.59 |
| $V_1T_{12}$ | Control | 65.44 | 65.43 | 65.43 |
| $V_2T_1$ | GA-50 ppm | 69.76 | 69.74 | 69.75 |
| $V_2T_2$ | Ca-0.10 Mm | 67.27 | 67.60 | 67.44 |
| $V_2T_3$ | Mo-0.014 mM | 69.46 | 70.14 | 70.80 |
| $V_2T_4$ | $ZnSO_4$ -0.5% | 69.12 | 67.38 | 67.55 |
| $V_2T_5$ | $FeSO_4$ -0.5% | 67.68 | 67.27 | 67.23 |
| $V_2T_6$ | BA-10 ppm | 68.70 | 69.04 | 68.87 |

| | | | | |
|---|---|---|---|---|
| $V_2T_7$ | B-0.015 mM | 67.72 | 67.40 | 67.96 |
| $V_2T_8$ | GA-50 ppm + $ZnSO_4$ -0.5% | 67.10 | 67.58 | 67.24 |
| $V_2T_9$ | GA-50 ppm + Mo-0.014 Mm | 70.95 | 71.61 | 71.28 |
| $V_2T_{10}$ | BA-10 ppm + $ZnSO_4$ -0.5% | 69.08 | 67.09 | 68.59 |
| $V_2T_{11}$ | BA-10 ppm + Ca-0.10 Mm | 69.45 | 67.76 | 68.11 |
| $V_2T_{12}$ | Control | 66.13 | 65.79 | 65.96 |
| | SEm. (±) | 0.92 | 1.41 | 1.46 |
| | CD at 5% | 1.23 | 1.36 | 1.28 |
| **Treated v per s control** | | | | |
| $V_1$ | Treated | 70.95 | 71.83 | 71.39 |
| $V_1$ | Control | 69.44 | 70.43 | 69.94 |
| $V_2$ | Treated | 70.53 | 71.63 | 71.08 |
| $V_2$ | Control | 69.13 | 69.79 | 69.46 |
| | SEm. (±) | 0.68 | 1.04 | 1.08 |
| | CD at 5% | 1.94 | 1.90 | 1.83 |

## Conclusion

In the present investigation, among the PGR's GA- 50 ppm was found to be the most effective than BA- 10 ppm in increasing morpho-physiological and growth parameters of groundnut varieties. Among the micronutrients Mo-0.014 mM, B-0.015 mM and Ca-0.10 mM% were found to be the most effective in increasing the pod yield and morpho-physiological characters. The foliar application of PGR's and MNR's and their combinations were found to be superior for increasing the translocation of assimilates toward the kernel development, various morpho-physiological characters, growth functions etc. of groundnut (cv. Phule Unnati and KDG-160). Among both the varieties, Phule Unnati showed numerically higher growth parameters *viz*. leaf area index, leaf area duration, phenological characters *viz*. total number of flowers per plant. The foliar spray treatment of GA-50 ppm and Mo-0.014 mM alone or in combination found to be the most beneficial in increasing the morpho-physiological traits of groundnut varieties mainly because of increased translocation efficiency of assimilates towards the development of economic components.

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