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Pattern of Growth and Dry Matter Accumulation in Some Improved Cowpea Varieties (*Vigna unguiculata*) Exposed to Alpha Nano Spin

Hauwa Ahmad Kana*, Emmanuel Enock Goler, Peter Barka Mshemlbula

Nanobiotechnology Research Group, Department of Botany, Faculty of Science, Federal University of Lafia, Lafia, Nigeria
Email: *hauwamakongiji@gmail.com

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Abstract

Ten (10) cowpea varieties exposed to alpha nano spin were evaluated during the 2019 cropping season to access the role of alpha nano spin in their growth and dry matter accumulation at the Botanical garden of Federal University, Lafia. A Randomized Complete Block Design (RCBD) with four replications was used. The fourth replication was used for the destructive sampling over time. The seed was exposed to alpha nano spin before planting at 0, 20, 40 and 60 minutes respectively. Results of the study showed that the varieties differed significantly with respect to morphological traits studied ($P < 0.05$) as exposed to the alpha nanoparticles. Morphological traits such as vine length, number of leaves and above ground stems were significantly influenced by alpha nano spin bombardment. 40 mins alpha nano spin resulted in maximum accumulation of dry matter, leaf area and leaf area index. The traits evaluated were stable under alpha nano spin exposure, suggesting that they could be useful indices in creating genetic variability in each of the varieties.

Keywords

Alpha Nano Spin, Cowpea Varieties, Growth and Dry Matter Accumulation

1. Introduction

Naturally occurring or engineered materials with at least one dimension and less than 100 nm in size are called nanomaterials. These nanomaterials are also characterized by a very high surface area to volume ratio contributing to their unique physio-chemical properties. This small size gives rise to properties different from those exhibited by the bulk material of the same composition. These new properties provide the material with an added value that has multiple applications in automotive, energy, pharmaceutical, medical and agricultural industries, among others.

It is estimated that more than 12,480 commercial products use nanomaterials including biological systems [1]. Since such materials are being extensively used, their global production has also increased dramatically, making it immensely important to monitor the response of living systems to such material exposure. Limited reports are available dealing with the effect of nanomaterials on plants and related ecosystems [2]. Although plants and microbes are continuously exposed to naturally occurring nanomaterials, exposure to engineered nanomaterials is relatively new and requires appropriate attention [3]. In the last decade, various researchers showed that nanomaterials affect plant growth and development and assessed their use in sustainable agriculture practices. [4] reported that the effect of Nano Particles (NPs) can be beneficial or harmful to plants depending on the type of nanomaterials used and their mode of application. Studies have demonstrated the uptake of NPs by different plants led to their accumulation in subcellular locations [5], to alterations of various physiological processes and induced plant growth and development [6]. Moreover, [7] revealed that silica-NPs induced seed germination, whereas the treatment with cadmium-selenide quantum dots restricted the germination. [8] showed that the higher concentrations of nano-sized Zn (35 nm) and ZnO (20 nm) inhibited the germination in ryegrass and corn, respectively.

2. Materials and Methods

The work was carried out in the Botanical garden of Federal University Lafia. Nine genotypes of cowpea were obtained from the Institute of Agricultural Research (IAR) Samaru, Zaria and one from Nasarawa Agricultural Development Program (NADP), Lafia was evaluated on the field in a randomized complete block design in four replications. The fourth replication was used for growth analysis studies. The cowpea were Sampea 12, Sampea 11, Sampea 10, Sampea 7, Lafia, Sampea 6, Sampea 8, Sampea 16, Sampea 17 and Sampea 5. Each plot size measuring 3 m × 3 m (9 m^2) was manually cleared using cutlass and ridges were made using a hoe. Two seeds each of the selected cowpea varieties were sown per hole with a planting depth of 2 cm, with an inter-row spacing of 75 cm and intra-row spacing of 50 cm respectively. Manually hoe weeding was carried out two weeks after planting and six weeks after planting. Data were collected on plant height and number of leaves from two weeks after planting and continued at fortnightly intervals until eight weeks after planting, pod length, number of seed/plant, number of pods per plant and 100 seeds weight were recorded. In the fourth replication, one plant per plot was uprooted, washed, cleaned off sand and separated into leaves, stems and roots. The plant parts were placed in separate calico bags and dried in a moisture extraction oven at 100˚C for 48 h to extract all moisture in the plant parts. Dry matter (DM) percent was calculated as the ratio of the dry weight to the sample fresh weight and multiplied by 100 as follows: DM = $b/a \times 100$, where a = Sample Fresh Weight and b = dry weight of sample.

Plants parameters measured: Number of leaves borne on each plant was counted and the mean value calculated and expressed as number of leaves per plant. The Leaf Area (LA) was estimated by the disc method on dry weight basis at different growth stages of 14, 28 and 42 DAP. Leaf Area Index (LAI) was also determined from LA using the relation:

$$\text{LAI} = \frac{\text{Leaf area of number of plants per meter sequare}}{1\ \text{m}^2 \text{ of land}}$$

Net Assimilation Rate (NAR) was calculated using the relation below according to the formula described by [9].

$$\text{NAR} = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{\ln LA_2 - \ln LA_1}{LA_2 - LA_1} \left(\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}\right)$$

where, W_1 and W_2 are total dry weight (above ground) at sampling periods T_1 and T_2 respectively and LA_1 and LA_2 are leaf areas at sampling periods T_1 and T_2, respectively.

Randomly selected plants from each variety were used as destructive sample at 14, 28 and 42 DAP for dry matter content determination on the leaves, stems and roots. These harvested plants (above-ground parts) from the net plot area were allowed to dry to a constant weight and recorded as total biomass of the plant. All the data collected were statistically analyzed and where the F-values were found to be significant, the treatment means were separated using Duncan's multiple range test except for total dry matter.

3. Results and Discussion

The Mean Number of leaves between treatments and varieties of improved cowpea varieties exposed to alpha nano spin were statistically significant at $P < 0.05$ (**Table 1**). The highest mean number of leaves was recorded by Lafia and this was significantly different from Sampea 12, Sampea 11, Sampea 16 and Sampea 8. Most of the varieties recorded their highest mean number of leaves at T_2. Response to moderate concentration of nanoparticles has been shown to increase growth in cowpea as reported by [10] who observed that cowpea responded positively toward silver nanoparticles at 50 ppm (T_2) concentration than the other levels of treatments. Also, [11] reported that T_2 treatment maintained higher zinc content as compared to T_1 and T_3 when cowpea leaves were treated with ZnO nanoparticles.

Leaf area and leaf area index: At 14 and 28 DAP, the effect of alpha nano spin on Leaf Area (LA) was not as significant ($p < 0.05$) as it was at 45 DAP. Leaf area increased consistently throughout the experimental period and was directly proportional to the age of the plant as observed in Sampea 11, Sampea 6, Sampea 8, Sampea 16, Sampea 5 and Lafia 2. Sampea 12 had the highest leaf area index

Table 1. Effect of variety and alpha nano particles on observed parameters.

	Mean Vine Length	Mean Number Of Leaves	Mean Number Of Branches	Leaf Area Index	Leaf Area (cm^2)	Net Assimilation Rate G^{-Rate}
Varieties						
Samp 12	146	415	2.96	2.77	1116.00	3.70
11	113	438	3.00	1.55	1252.00	3.35
10	168	550	2.79	1.38	960.00	3.74
7	174	550	3.62	1.23	911.24	3.24
Laf 2	94	564	2.79	1.79	1083.95	3.24
Samp 6	132	421	2.50	1.54	769.27	3.44
8	105	209	3.62	1.84	862.19	2.99
16	115	431	3.87	1.95	960.00	3.35
17	145	475	3.04	2.26	1089.04	4.14
5	735	469	2.58	2.06	1217.29	4.52
LSD	35.9	113.3	0.96	0.24	151.50	0.04
Alpha Nano Spin						
0	129	466	3.03	1.18	790.64	1.5
20	123	440	2.96	1.26	944.64	1.7
40	382	459	3.18	2.06	1288.88	2.0
60	137	444	3.19	1.71	790.54	1.9
LSD	NS	NS	NS	0.12	102.6	NS

followed by Sampea 7. Sampea 10 recorded the least, 769.27 cm^2. The leaf area differs significantly ($p > 0.05$) with alpha nano exposure (Table 1).

Leaf area also increased consistently with alpha nano spin exposure time as the plants grew. There was also sudden rise in leaf area with exposure time of 60 mins at 42 DAP. However, the optimal rate of alpha nano spin exposure time observed for greater leaf area was 40 min and this was consistent throughout the experimental period. This result compares favorably with the observation by [12] which reported the highest leaf area with 20 $kg \cdot ha^{-1}$ application.

Leaf Area Index (LAI) increased proportionally with age of the crop in all varieties, with Sampea 12 and Sampea 10 recording the highest and lowest LAI of 2.77 and 1.23, respectively (Table 1). However, varietal effect on leaf area index was significant ($p < 0.05$) at 45 and 60 DAP. The leaf area index differs significantly ($p < 0.05$) with alpha nano spin different exposure times. Alpha nano spin in this instance act as bio-stimulant described as general biological phenomena that are dependent on the interactions between cell molecular structures and external impulses or stimuli.

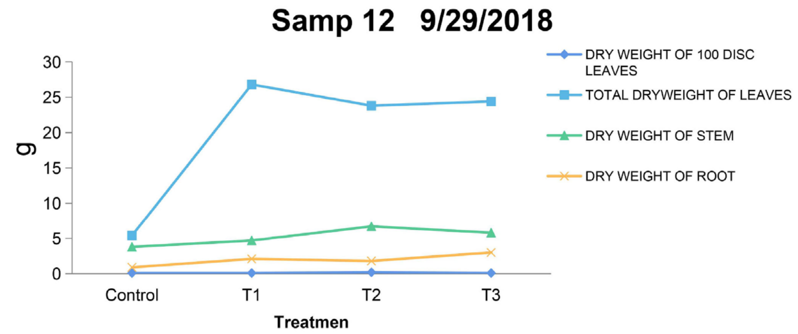
Number of primary branches per plant: In the present study, Sampea 16 produced the highest number of primary branches than the other varieties (Table 1). There was a significant ($p < 0.05$) varietal difference in the number of primary branches per plant, the highest number of branches was produced by

Sampea 16 which is significantly greater than Sampea 5, Sampea 10 and Laf variety. The variation in number of primary branches could partly be due to genetic makeup of the varieties [13] and weather conditions [14]. Alpha nano bombardment did not significantly affect number of branches. However, greater number of branches was recorded at 40 mins alpha nano spin throughout the experimental period (**Table 1**). This could be attributed to the fact that alpha nano spin is required in moderate quantities in shoot tips where metabolism is high and cell division is rapid.

Net assimilation rate: Net Assimilation Rate (NAR) recorded for each variety declined significantly with age of the plant. This was not significantly ($p < 0.05$) influenced by cowpea variety (**Table 1**) nor alpha nano spin exposure. However, Sampea 7 and Lafia variety recorded statistically similar NAR but these were significantly different from each other and this suggest why the leaves of the two varieties were more efficient in producing dry matter than the others. The reduction in NAR between sampling periods in some of the varieties agrees with the report by [15], attributing it to the fact that the plants had sufficient leaf area but there were; however, many leaves which had reduced assimilatory activity [16]. Higher NAR rates were recorded at alpha spin time of 0mins. The NAR decreased as alpha nano spin exposure time increases but at an irregular pattern.

Dry matter production, distribution and total biomass: Total Dry (leaves, stems and roots) Matter (TDM) produced per plant from 4, 6 and 8. Weeks After Planting (WAP) was affected by cowpea variety and alpha nano spin bombardment in the present study (**Figures 1-10**). Generally, TDM production increased progressively over time in the same pattern for Sampea 11, Sampea 17, Laf variety, Sampea 6. This is in agreement with [17] that dry matter production in plants gradually increases with crop age and attains maximum at maturity. Majority of the varieties peaked at 42 DAP. Sampea 11 and Sampea 6 peaked at 42 DAP under 40 mins (T_2) alpha exposure, Sampea 8 and Sampea 16 peaked at 42 DAP under 20 mins (T_1) alpha exposure, Sampea 10, Sampea 7 and Laf variety also peaked at 42 DAP but under 0 mins exposure (T_0) while, Sampea 5 also peaked at 42 DAP but at 60 mins alpha exposure (T_3). These results, therefore, show that the varieties have unequal or irregular growth patterns as well as dry matter production potential. In all varieties, alpha nano spin at 40 min (T_2) performed better than all treatments for total leaves dry weight and total stem dry weight. This result is in line with findings by [10] who reported significantly higher biomass in shoot of cowpea when treated with ZnO nanoparticles as compared with other non-nano treatments. These assimilations were not translated into number of seeds per pod or seed weight. Since assimilatory organs are entirely responsible for sustaining plant growth.

Dry matter production is influenced by genotype (variety) and alpha nanoparticles, therefore, the production of different dry matter content at different stages of the plant growth is based on the influence of the alpha nano spin, this attests to the fact that these varieties have different growth potentials. This agrees



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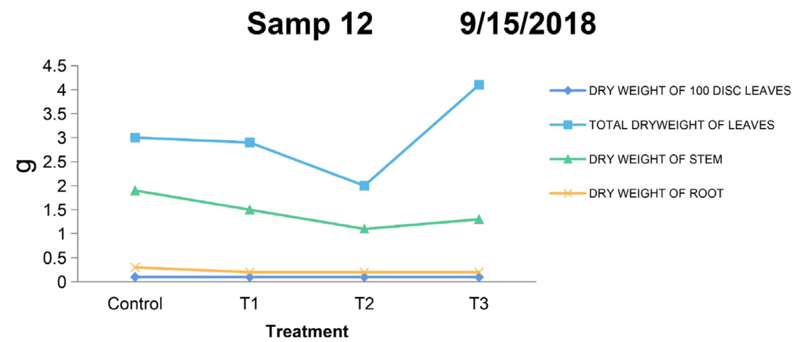

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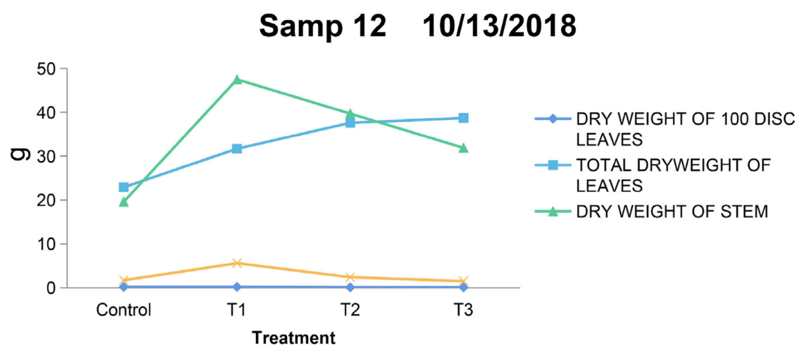

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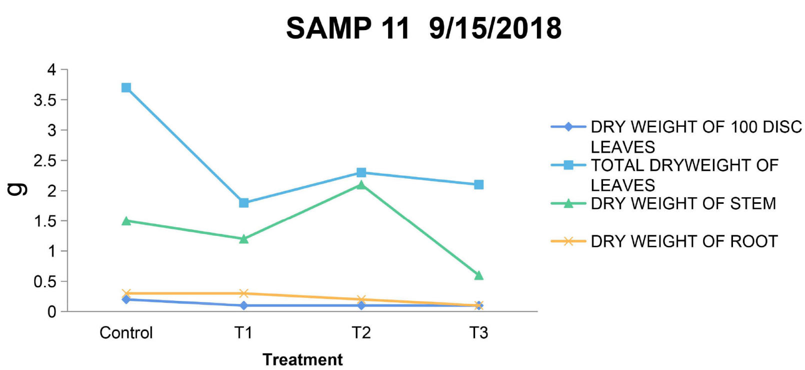
Figure 1. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 12 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 12 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 12 AT 56 DAP.



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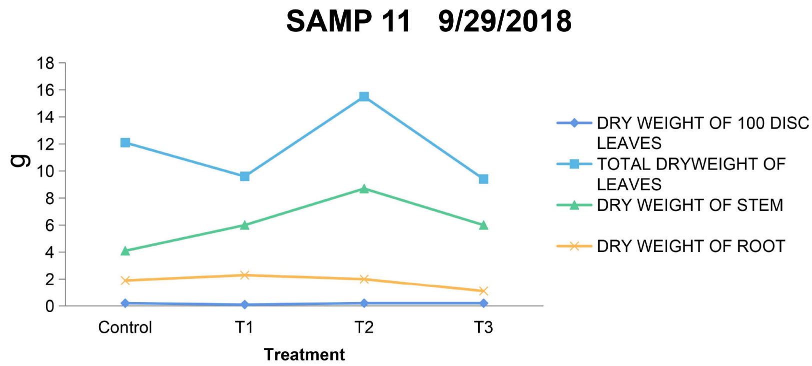

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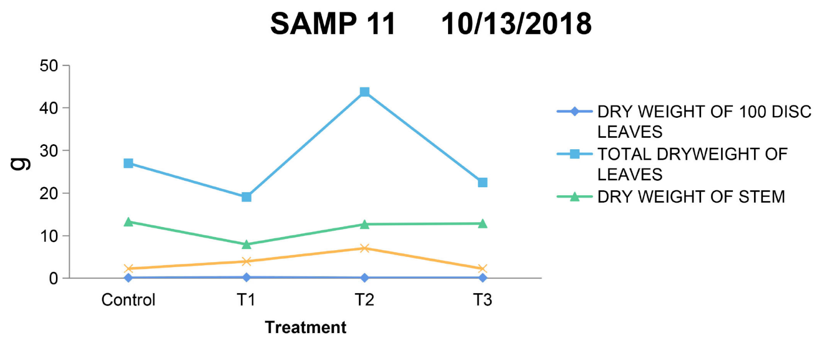

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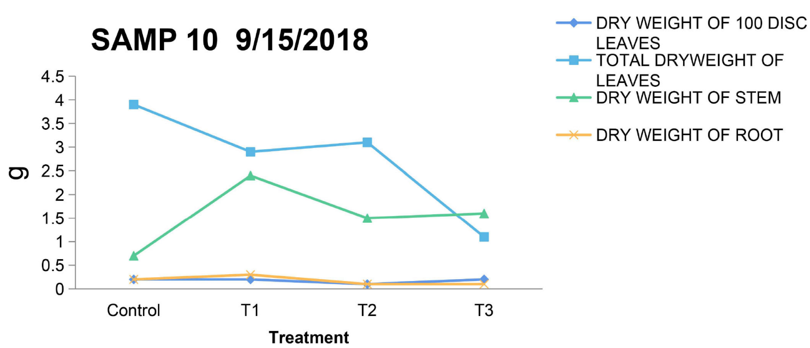
Figure 2. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 11 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 11 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 11 AT 56 DAP.



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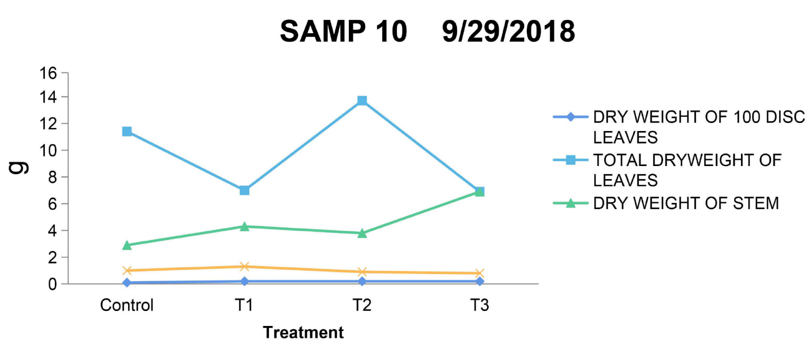

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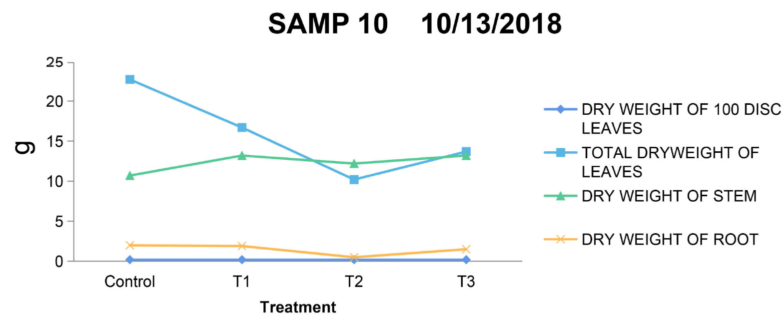

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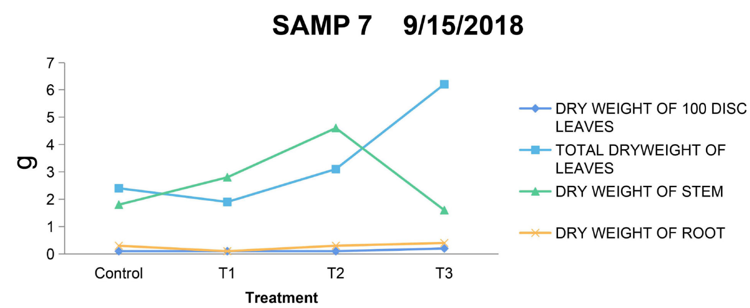
Figure 3. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 10 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 10 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 10 AT 56 DAP.



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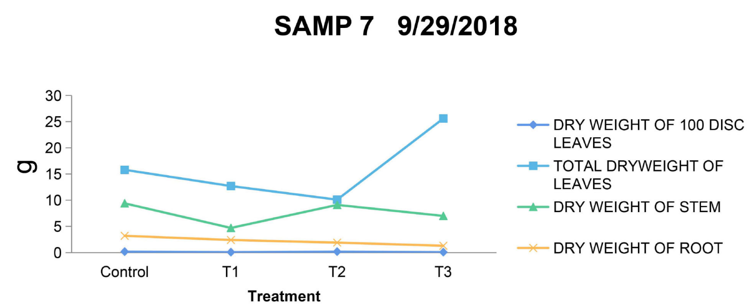

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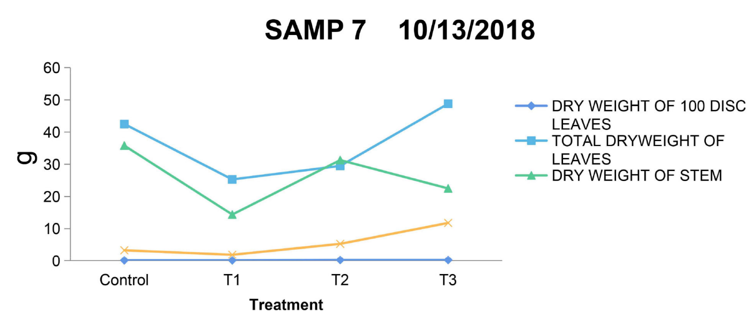

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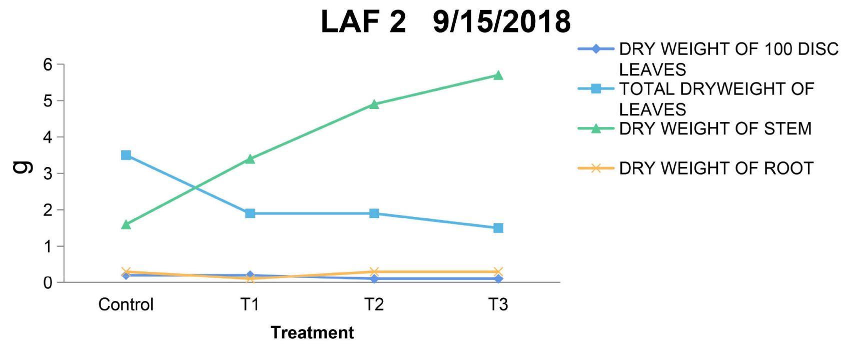
Figure 4. (a) Effect of alpha spin nanopaticles on dry matter partitioaing in SAMPEA 7 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 7 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 7 AT 56 DAP.



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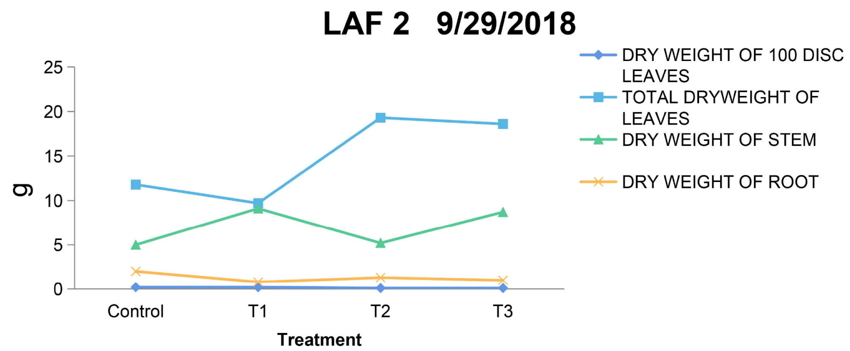

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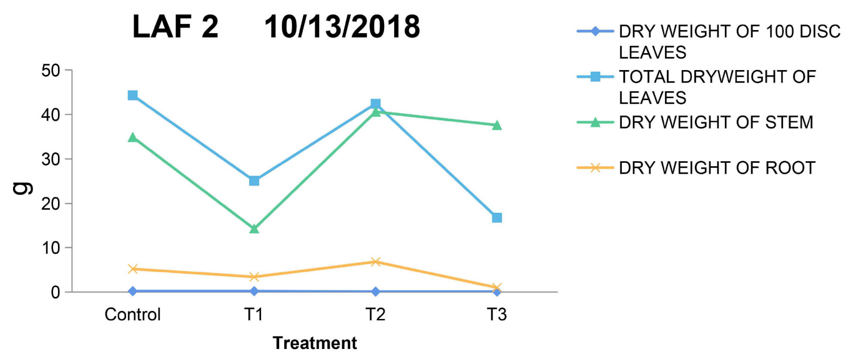

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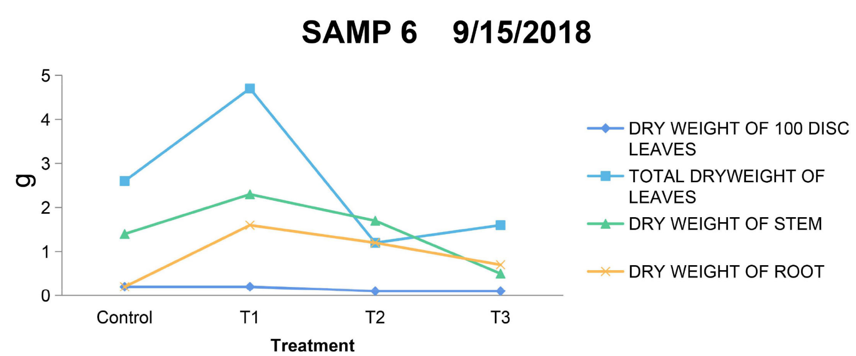
Figure 5. (a) Effect of alpha spin nanopaticles on dry matter partitioning in LAFIA 2 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in LAFIA 2 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in LAFIA 2 AT 56 DAP.



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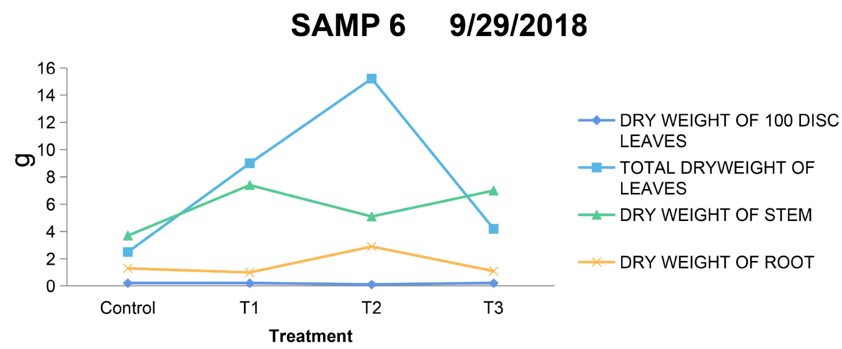

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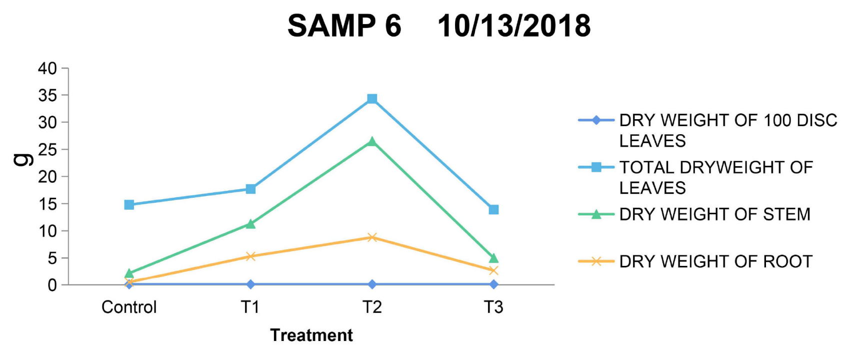

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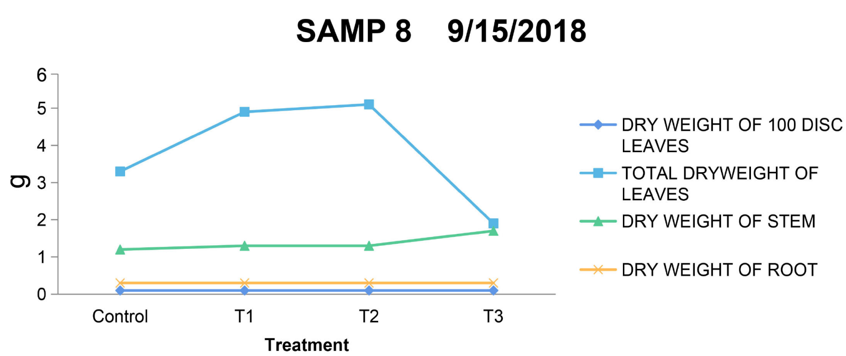
Figure 6. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 6 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 6 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 6 AT 56 DAP.



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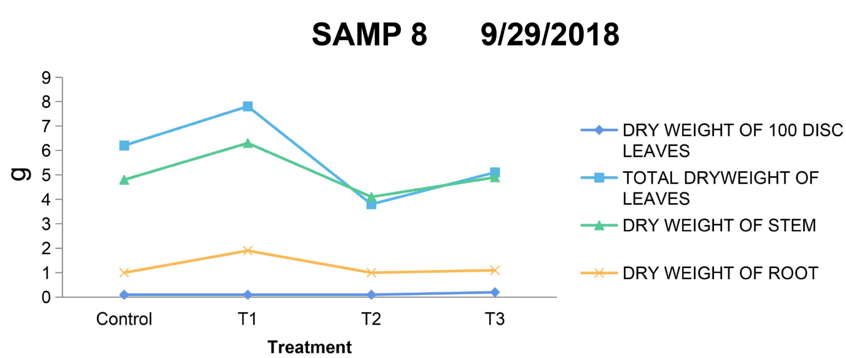

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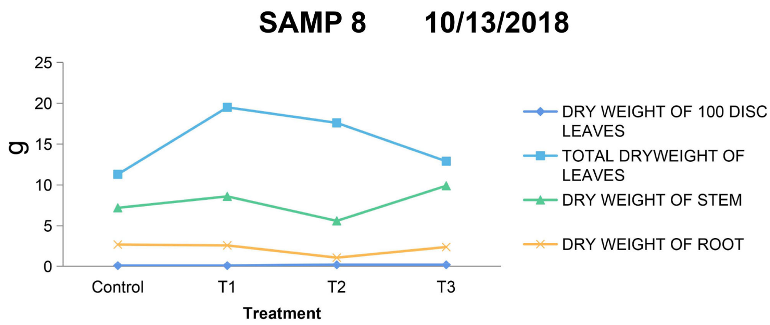

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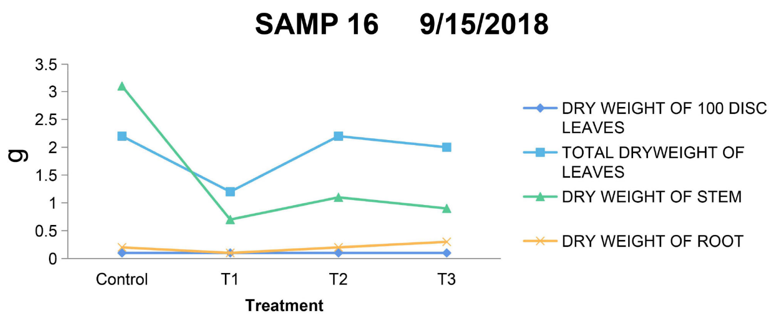
Figure 7. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 8 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 8 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 8 AT 56 DAP.



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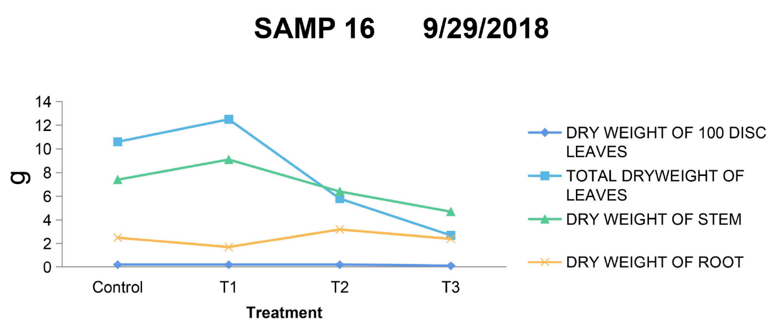

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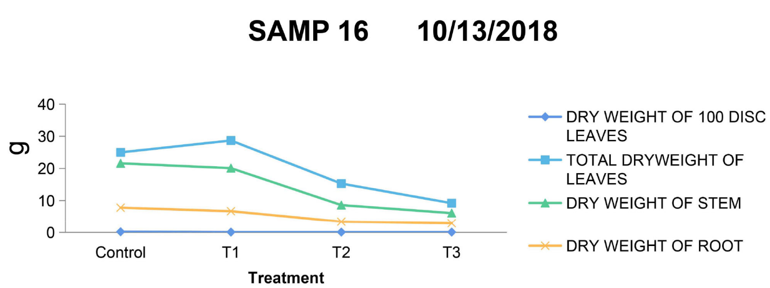

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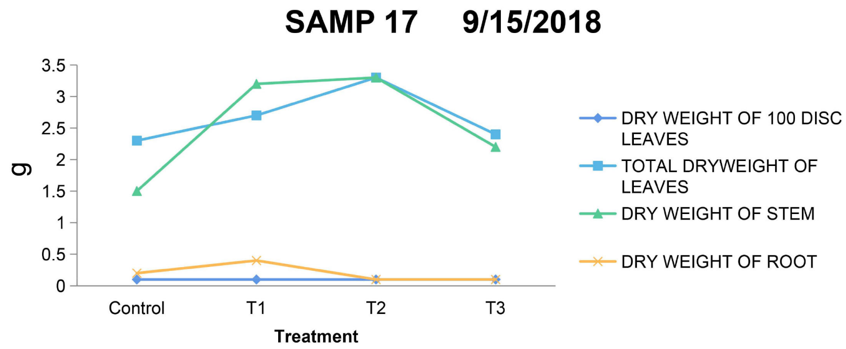
Figure 8. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 16 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 16 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 16 AT 56 DAP.



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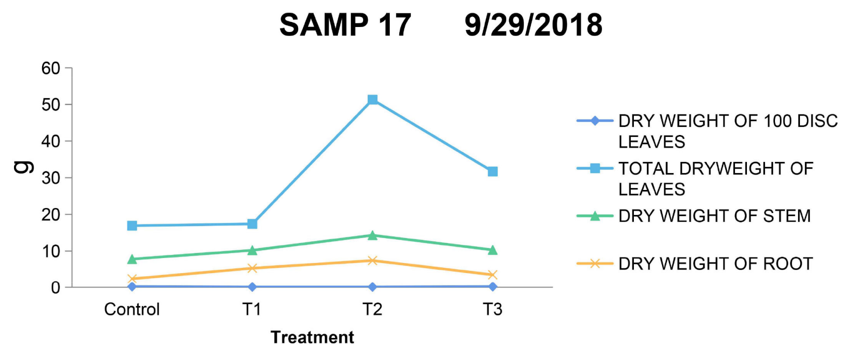

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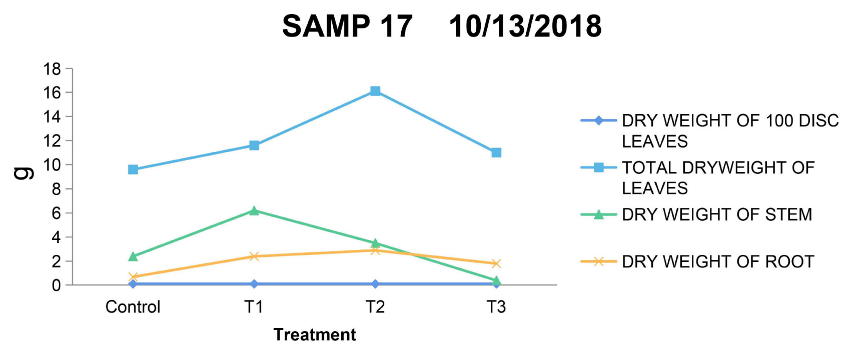

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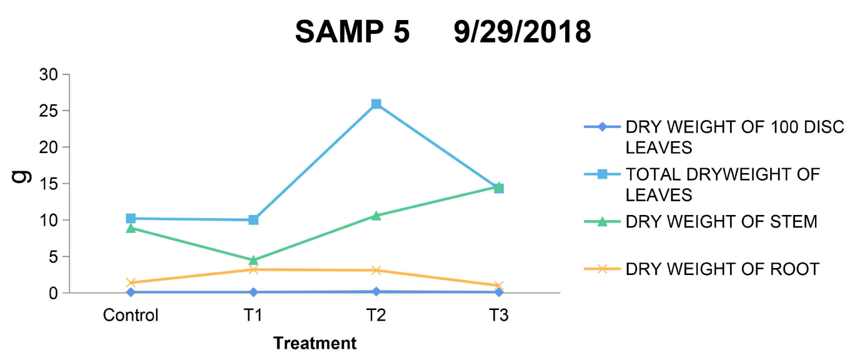
Figure 9. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 17 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 17 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 17 AT 56 DAP.



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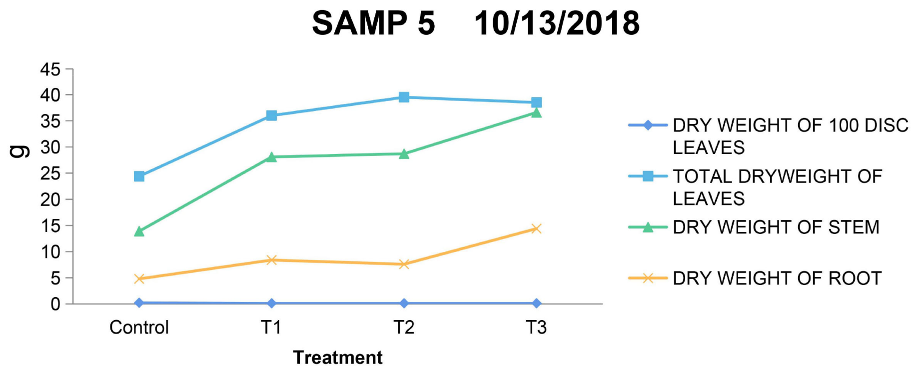

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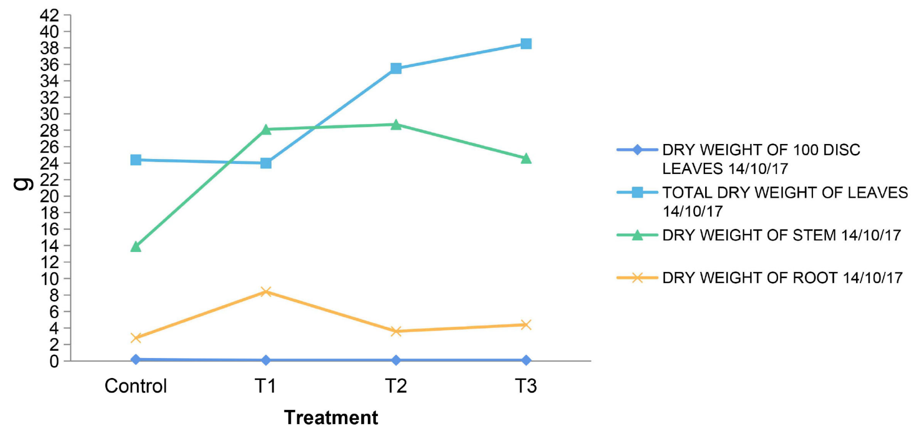

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Figure 10. (a) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 5 AT 28 DAP; (b) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 5 AT 42 DAP; (c) Effect of alpha spin nanopaticles on dry matter partitioning in SAMPEA 5 AT 56 DAP.

with the report by [14] that cowpea varieties have different capacities for dry matter production.

Generally, within 28 - 42 DAP, Dry Matter (DM) accumulation in the leaf and stem increased. However, there was a greater accumulation in leaf than in the stem. This could be attributed to production and formation of new leaves. However, there was a decline from 42-DAP, which may be due to mutual shading, competition, leaf senescence and translocation of photosynthates to other plant parts as reported by [17]. Sampea 17 followed by Sampea 12 and Sampea 12 and Laf variety had more accumulation of dry matter in their leaves than the others.

The results of this finding have shown that application of nanotechnology can bring about improvement as well as confront the different challenges facing the production of cowpea. This approach can represent an important alternative that may accelerate production of varieties with useful traits and when applied alongside conventional breeding will complement the efforts of breeders in overcoming challenges of cowpea production. The application of bio-stimulant usually brings about modification in gene expression among organisms.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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