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Alpha-Spin-Mediated Growth Improvement for Tomato (*Lycopersicon esculentum* Mill.) Varieties in Jauro Yinu, Ardo-Kola LGA, Taraba State

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Abstract

The study was conducted to investigate the improvement achieved through the treatment of two tomato varieties (ANSAL and Dan-Zaria) with Alpha-Spin® nanoparticles (ASNp) in a screenhouse at Jauro Yinu in Ardo-Kola LGA, Taraba State, Nigeria. Seeds were exposed to the (ASNp) for durations of 15, 30, 45, and 60 minutes before planting, using a Randomized Complete Block Design with a control group. The results of data collected and analyzed using GENSTAT statistical software showed that Alpha-Spin® treatments did not affect germination time (which was 7 days after planting for ANSAL and 3 days for Dan-Zaria in all exposures) or plant height (Dan-Zaria: 148.33 cm). However, it significantly improved other growth parameters, including stem girth (Dan-Zaria: 19.33 mm), number of branches (Dan-Zaria: 11), flowering time (27 days after transplanting for Dan-Zaria and 31 days for ANSAL with 15 minutes exposure), and number of flower clusters (ANSAL: 37). Overall, Dan-Zaria exhibited better growth than ANSAL in most of the growth parameters. These results indicate that exposure to ASNp enhanced the growth parameters like stem girth, number of branches per plant, and days to 50% growth) in tomato varieties, making it a recommended treatment for trait improvement in tomato breeding programs.

Keywords: Alpha-Spin, growth, improvement, Taraba, tomato

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most widely cultivated and consumed vegetable crops in the world, with significant nutritional and economic value [1]. However, tomato production is constrained by various biotic and abiotic factors, such as pests, diseases, drought, salinity, and nutrient deficiency, that adversely affect plant growth and yield [2, 3]. Nanotechnology, the manipulation of matter at the nanoscale (1–100 nm), offers a novel and promising approach to enhance crop productivity and quality by modulating various physiological and biochemical processes of plants [4, 5]. Nanomaterials (NMs), such as nanoparticles, nanotubes, nanofibers, nanocomposites, and nanoemulsions, have been shown to improve plant growth, yield, and stress tolerance by acting as antimicrobial agents, biostimulants, carriers, sensors, or catalysts [2, 3]. However, the effects of nanotechnology on tomato plants are still not well understood, and the underlying mechanisms of action are largely unknown. Moreover, the potential environmental and health risks of nanotechnology applications in agriculture need to be carefully assessed and minimized [3, 2].

Alpha Spin technology harnesses the power of quantum energy to enhance changes at the cellular level. The alpha spin plates release negative ions which are molecules that have gained additional negatively charged electrons and such negative ions are present in a wide spectrum of our diverse species [4, 7, 6]. . It has also been used in various studies to select useful variations in plants such as *Moringa oleifera* and Cowpea [4, 7, 6]. The technology involves bombarding the plants with ASNp, which results in additional variability in the plants [6]. The technology has shown promising results in improving the growth and dry matter accumulation of cowpea [7].

Nanotechnology, in general, is the study and application of extremely small things, typically less than 100 nanometers in size [8]. It involves the manipulation of matter at the atomic and molecular scale to create new materials and devices with unique properties and functions [8]. The purpose of nanofabrication is to produce nanoscale structures that form part of a system, device, or component in large quantities and at a very low cost [9]. It has potential applications in agriculture, such as improving food quality and safety, reducing agricultural inputs, and enhancing plant growth and yield [10].

Mittal *et al.* [11] have reported that nanoparticles are becoming a new material to transform modern agricultural practices. A wide range of nanoparticle-based solutions, such as pesticides, herbicides, fungicides, fertilizers, and nanoscale sensors, have been thoroughly researched for the purpose of enhancing plant health and soil quality.

Tomato contains higher amounts of lycopene, a type of carotenoid with antioxidant properties which is beneficial in reducing the incidence of some chronic diseases like cancer and many other cardiovascular disorders. This antioxidant property and its health benefits have raised the interest in tomato research and its consumption as a crop with medicinal properties [12].

The study aimed to investigate the effects of nanotechnology-mediated growth improvement in tomato varieties in Jauro Yinu, Ardo-Kola LGA, Taraba State, Nigeria, using Alpha-Spin® nanotechnology. Additionally, it sought to identify the optimal duration of exposure to Alpha-Spin® for each tomato variety to enhance tomato production in the study area. It was hypothesized that ASNp exposure can improve tomato growth and yield parameters by modulating the expression and activity of key genes and enzymes involved in plant development, photosynthesis, stress response, and secondary metabolism.

Material and Methods

The study area

Ardo Kola LGA is located between latitude 8°35'N to 9°08'N and longitude 10°52'E to 11°35'E, bordered by Lau LGA to the North, Jalingo LGA to the Northeast, Karim Lamido LGA to the West, Gassol and Bali LGAs to the South and Yorro LGA to the South east (Fig. 1). Ardo Kola LGA is one of the four LGAs created in 1996 in the state. It is made up of 10 political wards including Alimgora, Iware, Jauro Yinu,Lamido Borno, Mayo Ranewo, Sunkani, Sarkin Dutse, Zongon Kombi, Kofai and Tau. It was carved out of Jalingo LGA. The LGA has a population of 86,921 people (44,020 male, 42,901 female) according to the 2006 national population census. Ardo Kola has a land mass area of 2,312 km^2 [13].

Kofai ward is part of Jalingo town, the capital city of the state, but politically it is under Ardo Kola LGA. It is the most urbanized part of the LGA and forms a continuation of Jalingo metropolis. The study area houses important government institutions especially the Taraba State University main campus and Taraba State College of Agriculture [13]. Occupationally, Farming constitutes approximately 31.2% of all occupational categories among the residents in Kofai ward. Crops commonly cultivated in this location includes maize, sorghum, cassava, groundnuts, bell pepper, tomato, okra and a host of other vegetables. Apart from farming the residents are also engaged in commerce, artisanship, pottery, mat making, cattle rearing and a host of other engagements for their livelihood [13].

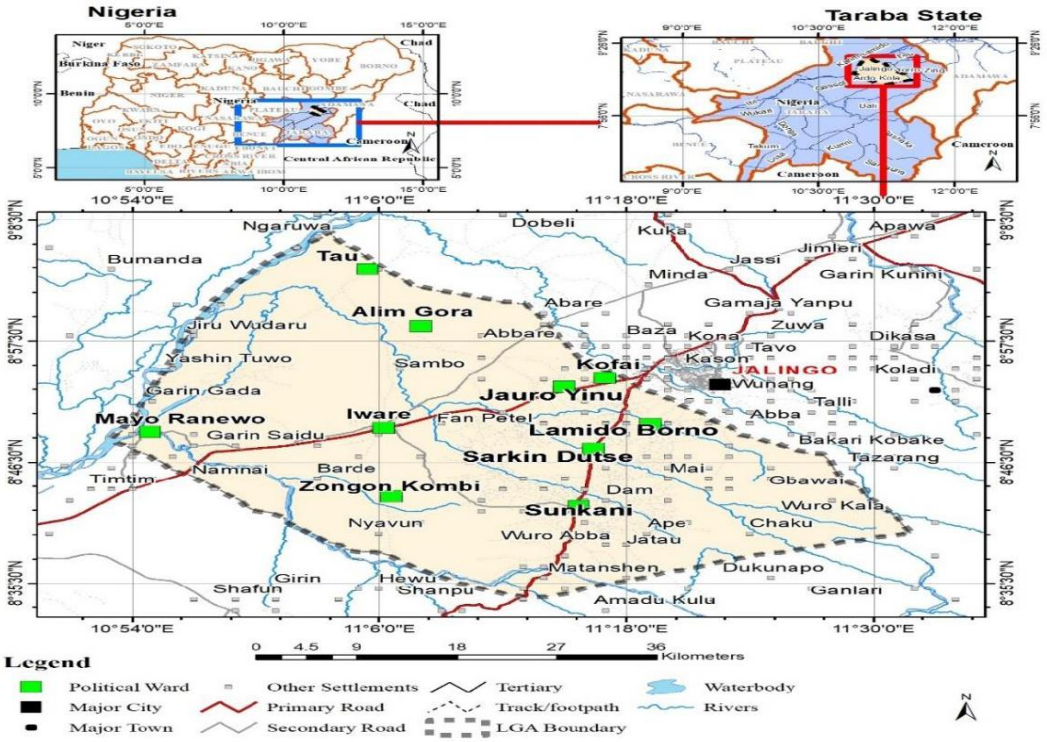

Figure 1: Map of Ardo-Kola showing the study area

Experimental design

A Randomized Complete Block Design (RCBD) having five (5) treatments and replicated thrice (3) was used for the potted experiment. Two tomato varieties were combined with four nanoparticles treatments and a control experiment replicated thrice. Two tomato varieties seeds were exposed to five levels of ASNp by placing the seeds on the disc as follows: zero exposure (Control) as T_0, 15 min exposure as T_1, 30 min exposure as T_2, 45 min exposure as T_3 and 60 min exposure as T_4.

Planting, raising seedlings and transplanting

Two (2) seeds were sown per hole at a depth of about 0.5 cm using a seedling tray which was then covered up with plastic wrap to trap in warmth and moisture [14]. Seedlings were thinned 2 – 3 days after the first true (non-cotyledon) leaves appeared [15]. Watering was at the rate of 15 ml per hole during first irrigation and then 7.5 – 10 ml per hole (morning and afternoon) [15]. Most vigorous seedlings were transplanted at the 4 or 5 leaf stage - 4 weeks old [16] into the polythene planting pots.

Two tomato varieties with different characteristics were selected and evaluated for their responses to different durations of Alpha-Spin® exposure under net-house conditions. Growth and yield parameters, including plant height, stem diameter, number of branches, number of days to 50% flowering, Number of flower clusters and fruits, fruit weight and size, and total yield were measured.

Data collection

Number of days to seed germination: This was recorded as the number of days it took from sowing to when the cotyledons of the tomato seed pops out of the soil to show the seed leaf.

Stem girth: This was measured at the thickest part of the main stem (the part closet to soil) using the electronic digital vernier calliper, recorded in millimetres. This was done fortnightly for the three replicates.

Number of branches per plant at maturity: This was recorded as the total number of off-shoots from the main stem of the plant at harvest.

Plant height at harvest: This was measured in centimetres (cm) using a measuring tape from the base of the stem (at the soil surface) to the top or the highest part of the plant (the tip of the apical bud) [17].

Number of days to 50% flowering: This was recorded as the total number of days it took from transplanting for the plants to produce the first flower(s) for each treatment group and replications.

The data collected from all the replicates of all these traits were subjected to statistical analysis including Analysis of Variance (ANOVA) and Principal Component Analysis (PCA) while the means were separated using the Least Significant Differences (LSD) at the 5% level of probability, using GENSTAT version 8.1.

Results and Discussion

The results of the effects of alpha nanoparticles exposure on the two tomato varieties on growth are presented in Tables 1 and 2. Results of the Analysis of Variance (ANOVA) revealed that for growth parameters, Days to Germination was earliest in Dan-Zaria (3 Days after Sowing) while for ANSAL it was 7DAS. Plant height (144.37 cm), Stem girth (16.91 mm), Number of branches (9.33) and Days to 50% flowering (27 days) were significantly higher ($p<0.05$) in Dan-Zaria than ANSAL (33.4 days). Considering duration of exposure to Alpha-Spin® nanoparticles, number of days to germination was not affected as all seeds subjected to different durations germinated within the same number of days, showing that exposure to Alpha-Spin® nanoparticles did not affect the seed germination time of the tomato varieties. This result did not follow the pattern observed by Carberry [18] who reported that Zinc oxide NPs have potential to boost the yield and growth of Peanut seeds and promote seed germination and likewise Holsapple *et al.* [19] who also reported improved parameters for seed germination as beneficial effects of nanopriming seeds.

Table 1: The effects of duration of Alpha-spin® exposure on some growth parameters of tomato (*Lycopersicum esculentum* Mill.) in Jauro Yinu

Treatment	Days to Germination	Plant Height (cm)	Stem Girth (mm)	No. of Branches	Days to 50% Flowering
Variety					
V_1	7.00	110.77	13.22	4.00	33.40
V_2	3.00	144.37	16.90	9.33	27.00
Significant	NS	*	*	*	*
$LSD_{(0.05)}$	0.0	10.79	1.78	1.36993	0.33
Treatment					
T_0	5.00	131.60	15.17	5.83	32.00
T_1	5.00	129.97	15.05	7.00	28.33
T_2	5.00	126.13	15.69	6.50	31.83
T_3	5.00	128.81	14.62	7.00	30.33
T_4	5.00	121.35	14.80	7.00	28.50
Significant	NS	NS	NS	NS	*
$LSD_{(0.05)}$	0.0	17.06	2.82	2.17	0.53
Interaction V x T	NS	NS	*	NS	*

V_1 = ANSAL, V_2 = Dan-Zaria, NS=Not significant,
* = Significant at 5%

Table 2: Principal component aAnalysis of the growth parameters of tomato as influenced by exposure to Alpha-spin^R Nanoparticles in Jauro-Yinu

Eigen value	7.5800	1.5168	1.0957
Proportion	0.689	0.138	0.100
Cumulative	0.689	0.827	0.927
Variable	PC1	PC2	PC3
Days to germination	0.356	-0.002	-0.073
Plant height (cm)	-0.339	-0.179	-0.054
Stem girth (mm)	-0.284	-0.413	0.250
No. of branches	-0.350	-0.067	0.188
Days to 50% flowering	0.322	-0.063	0.324
No. Flower clusters	-0.346	-0.117	0.095

Although the plant height did not vary significantly between the different exposure durations to the ASNp, the plants which received a minimum of 15 min exposure and above were taller than the control which were not exposed. This is in concordance with [6, 2, 1] who reported a significant difference in the mean plant height of cowpea (*Vigna unguiculata* L.) and Acha (*Digitaria exilis* Kippis Staph.) plants respectively after exposure to Alpha-Spin® treatments.

Stem girth showed no significant difference ($p>0.05$). Highest Stem girth was achieved upon 30 min exposure which also showed a significant interaction effect ($p<0.05$) between the variety and duration of exposure to the Alpha-Spin® nanoparticles, alluding to the report of [22], that application of 100 ppm of ZnO-NPs led to better performance of the growth attributes of tomato plants. Sturdier stems are necessary for greater resilience by the plant to pressures from within and outside the plant.

Branching in plants is an important characteristic as it gives the plant more surface area for leaf production which is essential for photosynthesis and providing shading for the ground which helps in moisture conservation for plant effective growth. Branching can also affect the yield and quality of tomatoes. The results in Table 1 shows that number of branches per plant were higher in plants resulting from seeds which were exposed to 15, 45 and 60 min of the Alpha nano spin before planting which corroborated the report by [21] that tiller number in *Digitaria exilis* Kippis Staph. were significantly affected when exposed to Alpha nano spin. This result also agrees with [22] who also reported that foliar application of 100 ppm ZnO-NPs performed best in terms of growth parameters, physiological traits, yield attributes, yield, and quality traits of tomatoes.

Number of days to 50% flowering was shorter (28.33 Days After Transplanting - DAT) as a result of 15 min exposure to the Alpha nano spin as compared to the control which took 32 DAT to attain 50% flowering. The result however, showed an interactive effect between variety and duration of exposure (Table 1). Wohlmuth *et al.* [20] had reported a similar result when cowpea varieties were exposed to Alpha nano spin for 40 min and flowered earlier (42.45 days) than the control (43.47) and other exposure durations, hence agreeing with the result of this study that Alpha nano spin exposure reduces the number of days to flowering hence favouring early fruiting.

The results of Principal Component Analysis (PCA) showed that 92.7% of total variation was contributed by the first three principal component axes implying a high selection stability of these traits in the growth improvement of the tomato varieties studied. Number of days to Germination and number of days to 50% flowering were the major contributors of the variation in PC1 which revealed 68.9%. PC3 accounted for 10% where Stem girth and Days to 50% flowering were the major contributors (Table 2).

Conclusion

The results of Analysis of Variance and Principal Components Analysis of the data collected from this study has shown that exposure to Alpha nano spin has the capacity to improve the growth parameters of tomato plants if the right duration of exposure is used. It can therefore be concluded, from this finding, that exposure to alpha nano spin positively influences the stem girth, number of branches per plant and number of days to 50% flowering of the tomato varieties used and should be utilized for enhanced growth performance that can improve traits that enhance better yields.

Conflict of interest: We wish to declare that, at no point was there any conflict of interest, from the start to finish of this study between the authors. It is with the consent of both authors that this submission is made for publication.

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