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RESEARCH ARTICLE

Additional variability in engineered Cowpea (*Vigna unguiculata* (L.) Walp) exposed to alpha-spin nano particles

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ABSTRACT
Field study was conducted at the Botanical Garden, Federal University of Lafia, between August and October 2017 to investigate the effect of alpha nano spin on nine advanced varieties of cowpea obtained from Institute of Agriculture Research (IAR), Zaria and one local variety from Nasarawa Agricultural Development Program (NADP), Lafia which served as the control. These seeds were exposed to alpha-spin nano-particles at four different periods; 20 mins, 40 mins and 60 mins termed as T1, T2 & T3 respectively while the untreated seeds 0 mins were termed T0 (control). The experimental design was a Randomized Complete Block Design with four replications. Data were collected on agronomic traits, yield components and grain yield, which were subjected to Analysis of Variance and Principal Component Analysis. Laboratory studies were also carried out to determine the pattern of Dry matter accumulation at two weeks interval for six weeks. Results of harvested seeds revealed that Sampea 5, inoculated at 40 mins treatment produced black seeds colour from brown seed colour parent. Results also showed a significant difference among treatments and varieties for mean plant height, the mean number of leaves, mean number of pods and mean pod length. Total dry matter accumulation of leaves, 100 disc leaves and stems over time varied among treatments and varieties. The first three Principal Components (PCs) accounted for 83.1% of the total variation implying their high selection stability. The detailed results are presented and discussed in this paper as a measure of the future selection of useful variants of the improved cowpea for sustainable cowpea production.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is a crop of tremendous economic value. It is being a major source of protein in West and Central Africa where more than 60% of the world's cowpea is being produced (1). Rural families derive food and animal fodder (1, 2) as well as cash from the production of this crop. The crop can fix about 240 kg ha^{-1} of atmospheric nitrogen and make available about 60–70 kg ha^{-1}nitrogenfor succeeding crops grown in rotation (3). Due to its tolerance for sandy soil and low rainfall, it is an important crop in the semi-arid regions across Africa and other countries (4). Most cowpeas grown on the African continent are, particularly in Nigeria and Niger (4). Insects are a major factor in the low yields of African cowpea crops, and they affect each tissue component and developmental stage of the plant. In bad infestations, insect pressure is responsible for over 90% loss in yield. Several insect pests attack all the growth stages of cowpea, but their economic importance is highly dependent on the environment (5, 6). Generally, field pests that cause significant losses in cowpea include the stem maggots (*Ophiomyia* spp., Diptera: Agromyzidae), foliage beetles (*Ootheca* spp., Coleoptera: Chrysomelidae), aphids (*A. craccivora*), flower thrips (*Megalurothrips sjostedti*, Thysanoptera: Thripidae), legume pod borers (*Maruca vitrata*, Lepidoptera: Pyralidae. This legume pod borer, *M. vitrata*, is the main preharvest pest of the cowpea) and the pod-sucking bug (PSB) complex. The major PSBs (Hemiptera: Coreidae) are the spiny brown bugs *Clavigralla tomentosicollis*, *C. schadabi*, *C. hystricodes* and *Anoplocnemis curvipes*. Others are the cosmopolitan green stink bugs, *Nezara viridula* and *Piezodorus guildinii* (Hemiptera: Pentatomidae); these are of minor economic importance but the losses reported suggest that any one major pests of cowpea

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can cause significant economic loss if not managed (6, 7).

The present protective measures of Addressing food insecurity resulting from low cowpea yields would require changes to growing more drought tolerant cultivars, using improved crop management practices such as time of planting and plant population, residue management, tillage and inputs, such as crop protection chemicals, mineral fertilizers, and Rhizobium inoculants (8).

Most pulses are self-pollinated crops; therefore, the breeding methods used in the past were introduction, selection and hybridization, followed by pedigree selection. In addition, special techniques like mutation through irradiation and polyploidy were also attempted to increase genetic diversity in order to develop disease resistant variety thereby increasing yield.

Nanotechnology is an exciting and powerful discipline of science. It altered the properties of the plant; these altered properties have offered many new and profitable products and applications (9). Alpha-Spin optimizes the natural frequency as it can increase harmony in a body by stimulating vital life energy. Any contact with Alpha-Spin, the molecular structure will create smaller clusters that will make penetration and absorption easy by fully optimizing the body's molecular and cellular functions via resonance and then forming a vortex that results in the expression of a quantum energy field which will exert its effect in the content of an organism body. Its functions include the improvement of absorptions and increase hydrations, improve micro circulation. It can also be used to facilitate the flow of energy through reflexology frequency, through which it can improve plant growth and seed germination and extend the shelf life of fruits and vegetables (10). Nano-products are used in agriculture to (i) obtain agricultural products more rapidly and with high yield, which, in turn, will lessen the use of water and energy and (ii) produce less waste. The goal is to provide more benign, efficient, cost-effective and sustainable agricultural practices and production (11). Various types of nano fertilizers are available that have been designed to deliver nutrients on as-needed basis for plant growth (11, 12). Nitrogen is also one of the most important plant nutrients but nitrogen use efficiency (NUE) is often as low as 30% in agriculture (13). The use of Nanoparticles in the growth of plant and control of plant disease is a recent practice (14). It can be helpful to increase the production of useful edible plants such as spinach, radish, rye or grain-like maize, rice and wheat (15). It also reveals completely new or improved properties based on specific characteristics such as size, distribution and morphology, if compared with large particles of the bulk material they are made of (16).

It was reported that maximum exposure of Moringa to alpha nano-spin particles of 1 hr (T4) and minimum exposure time of 5 mins (T1) enhanced growth of six different characters in the studied plant (17). It was also reported that, in cowpea and Brassica, a positive response was observed toward AgNPs, for cowpea, optimum growth promotion and increased root nodulation were observed at 50 ppm AgNPs treatment while improved shoot parameters were recorded at 75 ppm AgNPs in *Brassica* (13). It has been effectively used as an anti-fungal agent on potato dextrose agar (PDA) and 100 ppm of AgNPs was used (18). The germination of various crops has been reported to be improved by the application of nSiO_2 in maize (*Zea mays* L.) and tomato (*Lycopersicum esculentum* Mill.). It was reported carbon nanotubes in tomato (*L. esculentum* Mill.), mustard (*Brassica juncea*), black gram (*Phaseolus mungo*) and rice (*Oryza sativa* L.) (19, 20). Reports are on nanoTiO_2 in spinach (*Spinacia oleracea*) and wheat (*Triticum aestivum* L.) (21-23). Reports are also on Nano Si, Pd, Au, Cu in lettuce (*Lactuca sativa*) (23, 24). Nanofertilizers have proved to be another landmark in the history of crop production through nanotechnology. There are many issues with the use of traditional chemical fertilizers, however, low use efficiency is the prominent one, which not only increases the cost of production but also causes environmental pollution (26). Nanofertilizers have been proven more efficient as compared to the ordinary fertilizers as these reduce nitrogen loss due to leaching, emissions and long-term incorporation by soil microorganisms (27). Nanosilica has been successfully used for the transfer of targeted genes into the cells (28) and this technique could also be used in the formulation of pesticides, insecticides and insect repellents (29, 30). Nanotechnology application has the potential to protect plants, monitor plant growth, detect plant disease and increase global food production, enhance food quality and reduce waste sustainable intensification (31). The objective of this research is to evaluate the variability of morphological characteristics, minimize grain losses and increase yield through the use of nanotechnology for further breeding programme

Materials and Methods

The work was carried out in the Botanical garden of Federal University Lafia. Nine genotypes of cowpea obtained from the Institute of Agricultural Research (IAR) Samaru, Zaria, Nigeria and one local variety from Nasarawa Agricultural Development Programme (NADP), Lafia. These different seed varieties were exposed to alpha spin nanoparticles at 20 mins, 40 mins and 60 mins termed as T1, T2 and T3 respectively while the untreated seeds 0 min were termed T0 (control) (Fig. 5). The seeds were evaluated on the field in a Randomized Complete Block Design with four replications. The fourth replication was used for growth analysis studies. The cowpea used were Sampea 12, Sampea 11, Sampea 10, Sampea 7, and Lafia variety, Sampea 6, Sampea 8, Sampea 16, Sampea 17 and Sampea 5. Each plot size measuring 3 × 3 m (9 m^2) was manually cleared, and 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. Temperature ranged between 20 ^oC – 32 ^oC with an average rainfall of 238 mm – 234 mm (August to October). Manually hoe weeding was carried out at two weeks after planting and six weeks after planting. Data were collected on plant height and

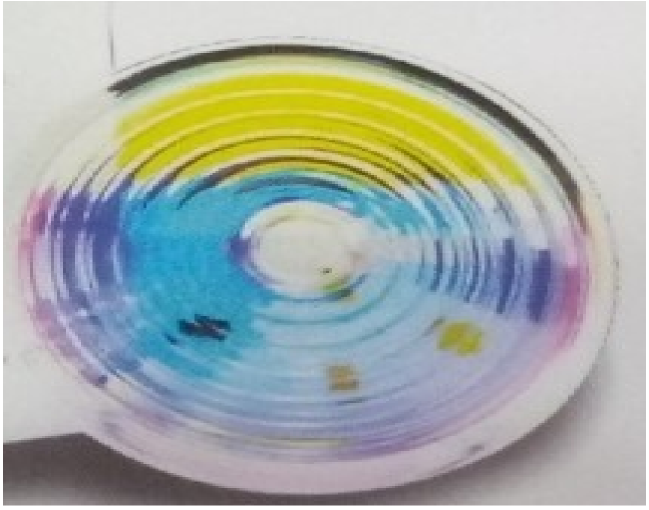

Fig. 4. Alpha nano spin disc.

Fig. 5. Cowpea seeds exposed to alpha nano spin.

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 the 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 hr to remove 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 the sample.

The importance of aspects related to dry matter accumulation as well as the distribution of assimilates have been demonstrated (32).

Results and Discussion

Field Observations of the cowpea genotypes revealed a wide range of variation of the different traits. Some had spreading growth habit while others were erect. Plant height, number of leaves, number of pods per plant, number of seeds per pods, pod length, 100 seeds weights and yield varied among treatments and varieties.

The results obtained from the analysis of variance revealed a significant difference in Mean plant height (Table 1). The result showed that the highest mean height was recorded by Sampea 7 (238.1 cm) T2 which was not significantly different from Sampea 10 (195 cm) T3, but these were significantly different at P<0.05 with all the treatment in Sampea 11, Sampea 6, Sampea 8, Sampea 16 and Sampea 5 which each recorded their highest plant height at (135.4 cm) T1, (128.2 cm) T2 and (108.4 cm) T2, (125.7) T3, (148.5) T2 respectively. All the treated plant varieties showed better plant height as compared to their control plants. This was also observed by earlier studies (33) that cowpea plants treated with ZnO nanoparticle all did better than their control plants. This too, improved plant growth in Mung bean seedlings (*Vigna radiata*) (34).

Mean number of leaves

The Mean Number of leaves among treatments and varieties of improved cowpea varieties exposed to alpha nano spin were statistically significant at P<0.05 (Table 2). The highest mean number of leaves was recorded by Lafia (119) T1 and this was significantly different from all varieties and their different treatment levels. Lafia (93.2) T2 and (89.0) T1 were not significantly different from Sampea 8 (85.2) T1, Sampea 8 (80.9) T2 and also Sampea 12 (79.4-T2) but were significantly different from the others. Sampea 12, (79.4), Sampea 11, (66.0), Sampea 7, (72.0), Sampea 16, (72.2) and Sampea 5, (72.4) all recorded their highest mean number of leaves at T2.

Table 1. Plant height

Treatment	Sample										Mean	
	Samp12	Samp 11	Samp 10	Samp 7	Laf 2	Samp 6	Samp 8	Samp 16	Samp 17	Samp 5		
Control	121.6	113.5	164.3	147.7	124.2	99.6	98.7	117.5	160.4	137.0	128.45	
T1	159.1	135.4	121.1	148.2	180.3	120.4	95.1	100.5	82.3	106.5	124.90	
T2	127.8	112.1	126.5	238.1	117.6	128.2	108.4	95.9	157.3	148.5	136.04	
T3	126.6	100.9	195.8	109.1	109.9	123.7	101.3	125.7	169.6	121.1	128.40	$LSD_{0.05}$= 54.7
Mean	133.8	115.5	151.9	160.8	133.0	118.0	100.9	109.9	142.4	128.3		
$LSD_{0.05}$	86.4											

Table 2. Mean of leaves

Treatment	Sample											
	Samp12	Samp 11	Samp 10	Samp 7	Laf 2	Samp 6	Samp 8	Samp 16	Samp 17	Samp 5	Mean	
Control	48.8	64.2	33.6	50.4	119.0	68.6	91.8	72.6	49.1	70.4	66.85	
T1	66.6	64.6	37.3	60.0	114.7	54.6	85.2	70.7	56.0	62.5	67.22	
T2	79.4	66.0	25.0	72.0	89.0	47.7	80.9	72.2	43.4	72.4	64.80	
T3	75.5	60.6	34.0	69.3	93.2	61.7	62.5	51.1	64.3	54.6	62.68	$LSD_{0.05}$ = 13.59
Mean	67.58	63.85	32.48	62.925	103.98	58.15	80.1	66.65	53.2	64.98		
$LSD_{0.05}$					21.49							

Response to moderate concentration of nanoparticles has been shown to increase growth in cowpea as reported in similar works (13), who observed that cowpea responded positively toward silver nanoparticles at 50 ppm (T2) concentration than the other levels of treatments. Also, (33) reported that T2 treatment maintained higher zinc content as compared to T1 and T3 when cowpea leaves were treated with ZnO nanoparticles. Lafia, Sampea 6, Sampea 5 had their highest mean number of leaves at T0, Sampea 10 (37.3) and Sampea 17 (64.3) peaked differently at T1 and T3 respectively.

Means number of pods per plant at harvest

The mean number of pods per plant was also significantly affected by alpha nano spin (Table 3). Increase in the mean number of pods was recorded for all the varieties treated with alpha nano spin as compared to each of their controls. The highest mean number of pods per plant was recorded by Sampea 10 (60.3) T2 followed by Sampea 12 (50.7) T3 and the lowest is recorded by Sampea 8 (7.0) T3. For the different spinning time, T2 treatments had more number of pods per plant compared to T1 and T3. It was reported that pod numbers in cowpea treated with ZnO nanoparticles were more as compared with zinc non-nanoparticle (33).

Mean Number of Seeds/pod

The number of seeds/pod was markedly affected by varieties and nanoparticles (Table 4). Regarding the main effect, the highest (14.03) and lowest (11.33) mean numbers of seeds per pod were recorded from Laf 2 spun at (40 min). T2 and Sampea 8 spun at (20 min) T1 respectively. Differences between Lafia (14.03) T2, Sampea 5 (14.03) T2, Sampea 5 (13.87) T1 and Sampea 5 (13.77) T3 were not statistically significant but statistical difference existed between these varieties and all the other spinning time for Sampea 12, Sampea 11, Sampea 10, Sampea 7, Sampea 6, Sampea 8 and Sampea 16. The report is in agreement with the earlier findings (7, 33), that different cowpea varieties have different genetic makeup as such they have a different number of seeds. Similarly, the number of seed per pod was significantly increasing with the increase in alpha nano spin where the highest was Lafia T2 (14.03) and Sampea 5 (14.03) T2 and the lowest was Sampea 8 T1 (11.33).

Mean Pod Length at Harvest

Mean length at harvest varied significantly among varieties and treatments (Table 5). The longest pod length was recorded by Sampea 5 (17.37 cm) T2 followed by Sampea 11 (17.20 cm) both T1 and T2, which were not significantly different from each other. Lafia (14.13 cm) T1 had the shortest pod length.

Table 3. Mean number of pods

Treatment	Sample										Mean	
	Samp12	Samp 11	Samp 10	Samp 7	Laf 2	Samp 6	Samp 8	Samp 16	Samp 17	Samp 5		
Control	46.7	30.1	35.2	24.8	30.8	34.7	11.3	26.4	22.0	52.1	31.41	
T1	16.1	32.8	24.5	30.5	43.2	20.1	21.9	18.5	26.0	23.2	25.68	
T2	50.7	30.5	60.3	35.0	31.9	17.1	24.5	32.3	27.0	31.1	32.37	
T3	46.7	41.6	25.2	19.7	22.1	41.0	7.0	29.6	39.6	58.0	33.05	$LSD_{0.05}$= 9.12
Mean	36.88	33.75	36.3	27.5	32.0	28.23	16.18	26.7	28.65	41.1		
$LSD_{0.05}$					14.42							

Table 4. Mean number of seeds per pod

Treatment	Sample										Mean	
	Samp12	**Samp 11**	**Samp 10**	**Samp 7**	**Laf 2**	**Samp 6**	**Samp 8**	**Samp 16**	**Samp 17**	**Samp 5**		
Control	12.40	13.00	12.00	12.27	12.40	11.70	11.63	11.30	13.43	11.80	12.19	
T1	12.50	12.30	12.17	12.50	12.00	12.63	11.33	12.40	12.83	13.87	12.45	
T2	12.47	12.13	12.03	11.80	14.03	12.87	12.43	12.63	13.13	14.03	13.94	
T3	12.93	12.83	12.10	12.17	12.83	12.47	12.50	12.90	13.63	13.77	12.81	$LSD_{0.05}$= 0.764
Mean	12.58	12.57	12.08	12.19	12.82	12.42	11.97	12.31	13.26	13.37		
$LSD_{0.05}$					1.208							

Hundred Seeds Weight

Hundred seeds weight was significantly ($P<0.05$) affected by variety and inoculation (Table 6). Regarding the main effect, the heavier seed weight (18.83 gm) and (18.27 gm) were recorded with Sample 8 (T2) and Sampea 10 (T2) respectively while the lighter seed weight was recorded by Sampea 5 (T0). The significant difference in hundred seed weight among the varieties may be due to the difference in translocation and partitioning efficiency of assimilating from source to sink (36). Although Sampea 8 and Sampea 10 all had a lower accumulation of dry matter in both stems and leaves but produced seeds heavier than others, this could probably be due to stimulating effects of the T2 alpha nano spin on the genotypes. Lafia T0 (119) had more No. of leaves, but the seed weight is significantly different from that of Sampea 8 (T2) and Sampea 10 (T2) respectively.

Likewise, 100 seed weight significant increased with alpha nano spin where the maximum was (18.83 gm) and the minimum was (13.93 gm) value obtained from T2 and T0 respectively. Similarly, findings were also reported (35) where inoculation brought a significant effect on seed weight of chickpea.

Grain yield

Alpha nano spin inoculation of cowpea varieties significantly affected the grain yield/ha (Table 7). Among the varieties, significantly highest grain yield was recorded by Sampea 8 (502.1kg/ha) T2 followed by Sampea 10 (487.2 kg/ha) T2 and the lowest grain yield among the varieties is mainly due to differences in the inherent yielding potential of the varieties. Similarly, (38) observed a significant variation in grain yield of some improved varieties of cowpea and these were attributed to the genetic variations in the examined varieties. Similarly, the increase in grain yield due to alpha nano inoculation may be attributed to the effectiveness of the nanoparticles in fixing Nitrogen (N) thereby meeting the nutrient requirements of the varieties. Also, (37) reported that T1O2 nanoparticles promoted nitrogen metabolism in the plant leading to the growth of the plant as a whole as observed in this research (Table 8).

Dry matter accumulation at 2, 4, 6 and 8 weeks after planting the ten varieties differs significantly due to the different alpha nano spins (Fig. 1 & 2). Highest dry matter accumulation in leaves was recorded in Sampea 12 followed by Sampea 5 and the lowest was recorded by Sampea 8 followed by Sampea 10. Stem dry weight accumulation was higher in Sampea 12, which is not significantly different from Sampea 7, Lafia and Sampea 5. The lowest was recorded by Sampea 10. Sampea 7 and Sampea 5 had more root dry matter than the other varieties. In all varieties, alpha nano spin at 40 min (T2) performed better than all treatments for whole leaves dry weight and total stem dry weight. This result is in line with findings (31) which reported

Table 5. Mean pod length

Treatment	Sample										Mean	
	Samp12	Samp 11	Samp 10	Samp 7	Laf 2	Samp 6	Samp 8	Samp 16	Samp 17	Samp 5		
Control	16.30	16.17	15.87	15.33	15.23	16.23	14.77	15.53	15.97	14.70	15.61	
T1	15.03	17.20	14.23	15.50	14.13	16.03	15.70	15.27	16.13	16.03	15.52	
T2	15.37	17.20	15.20	14.17	14.67	15.23	16.20	16.53	15.23	17.37	15.71	
T3	16.37	16.60	14.70	15.20	15.13	16.13	14.90	16.57	15.90	16.70	15.82	$LSD_{0.05}$= 0.866
Mean	15.77	16.79	15.0	15.05	14.79	15.91	15.39	15.98	15.81	16.2		
$LSD_{0.05}$					1.369							

Table 6. Mean 100 seeds weight

Treatment	Sample											
	Samp12	Samp 11	Samp 10	Samp 7	Laf 2	Samp 6	Samp 8	Samp 16	Samp 17	Samp 5	Mean	
Control	16.43	16.07	18.20	15.63	16.00	17.23	15.27	14.70	15.47	13.93	15.89	
T1	15.83	17.80	16.37	15.40	14.17	16.77	17.93	15.50	17.43	15.53	16.27	
T2	15.93	17.20	18.27	15.40	16.90	17.33	18.83	17.30	15.23	17.23	16.92	
T3	17.37	17.80	16.93	15.33	17.07	17.77	14.13	16.27	16.97	17.33	16.70	$LSD_{0.05}$= 1.132
Mean	16.39	17.21	17.4425	15.44	16.035	17.275	16.54	15.9425	16.275	16.005		
$LSD_{0.05}$					1.789							

Table 7. Grain yield kg/ha

Treatment	Sample										
	Samp12	Samp 11	Samp 10	Samp 7	Laf 2	Samp 6	Samp 8	Samp 16	Samp 17	Samp 5	Mean
Control	438.1	428.5	485.3	416.8	426.6	459.4	407.2	392.0	412.5	371.4	423.78
T1	422.1	474.6	436.5	410.6	377.8	447.2	478.1	413.3	464.8	414.1	433.91
T2	424.8	458.6	487.2	410.6	450.6	462.1	502.1	461.3	406.1	459.4	452.28
T3	463.2	428.5	451.2	408.8	455.2	473.8	376.8	433.8	452.5	462.1	440.59
Mean	437.1	447.6	465.1	411.7	427.6	460.6	441.1	425.1	434.0	426.8	
$LSD_{0.05}$					36.3						

significantly higher biomass in the shoot of cowpea when treated with ZnO nanoparticles as compared with other non-nano treatments. Also (38) increase in *Vigna radiata* dry weight when treated with sulfur NPs 500, 1000, 2000 and 4000 ppm. These assimilate were not translated into the number of seeds per pod or seed weight. Since assimilatory organs are entirely responsible for sustaining plant growth. The large quantity of dry matter in Sampea 12 and Sampea 5 but low weight output as compared to Sampea 10 and Sampea 8 can be due to delay in loading labelled assimilate into translocatory system or as a result of profile shape, location of advancing front which depends on the sensitivity in the radioactivity detecting system.

Table 8. Principal component analysis - Eigen analysis of the Correlation Matrix

Eigenvalue	2.4536	1.6451	0.8892
Proportion	0.409	0.274	0.148
Cumulative	0.409	0.683	0.831
Variable	**PC1**	**PC2**	**PC3**
Plant height	-0.564	-0.110	-0.313
Mean of leaves	-0.555	-0.274	-0.271
Mean of poe	0.349	-0.458	0.250
Mean of seed per pod	0.116	-0.713	0.027
Pod length	0.332	-0.280	-0.710
Mean of 1000 seed weight	0.356	0.341	-0.510

Sampea 5 brown seeds colour inoculated at 60 mins (T4) reproduces among its brown seeds progenies some black colour of seeds (Fig. 3). This additional colour variability may be as a result of the interactive effect of structural rearrangement of chemical compounds in the genes among the parent. Grain coat pattern in cowpea is obtained as the result of two interactions between two major genes “A and B” (38). The “A” gene which is dominant over “B” codes for black grain testa. Studies also reported that the mode of inheritance of seed coat colour in cowpea is complex, this is because several genes are involved and they interact to produce a varying pattern of seed coat colour (40). In this study, Sampea 5 was not crossed with any parent, so the alpha nano spin could have resulted in the configuration of molecular structures of the affected genes, and this contradicts an earlier finding (43) that there was no significant (p>0.05) effect of radiation on sensory attributes like flavour, taste, texture, softness and colour of cowpea.

The PCA conducted on the data, generated 7 component axes with eigenvalues ranging from 0.40–2.45. The first three principal components (Table 8) with an eigenvalue greater than 0.40 together accounted for about 83% of the total variation. The first principal component (PC1) contributed approximately 41% which plant height and mean number of leaves were the major contributors of the observed variation in PC1. The second principal component (PC2) contributed about 27% of the variation mainly observed through such as the mean number of seeds/pod and mean number of pods. The third PC accounted for another additional approximately 15% of the total variation in which pod length and mean 100 weights were major contributors. The PCA showed that mean plant height and mean number of leaves contributing the largest variability suggesting that they can be the main morphological traits to consider for a good yield.

Conclusion

Experimental findings of the present study indicated that higher level of alpha nano spin T2 (40 mins) exposure increased the growth of the improved cowpea in terms of height, number of pods, number of seeds, 100 seeds weight, grain yield and dry matter accumulation in leaves, stem and roots, in most of the observed varieties. It was reported that the best performing Acha varieties were those exposure to 60

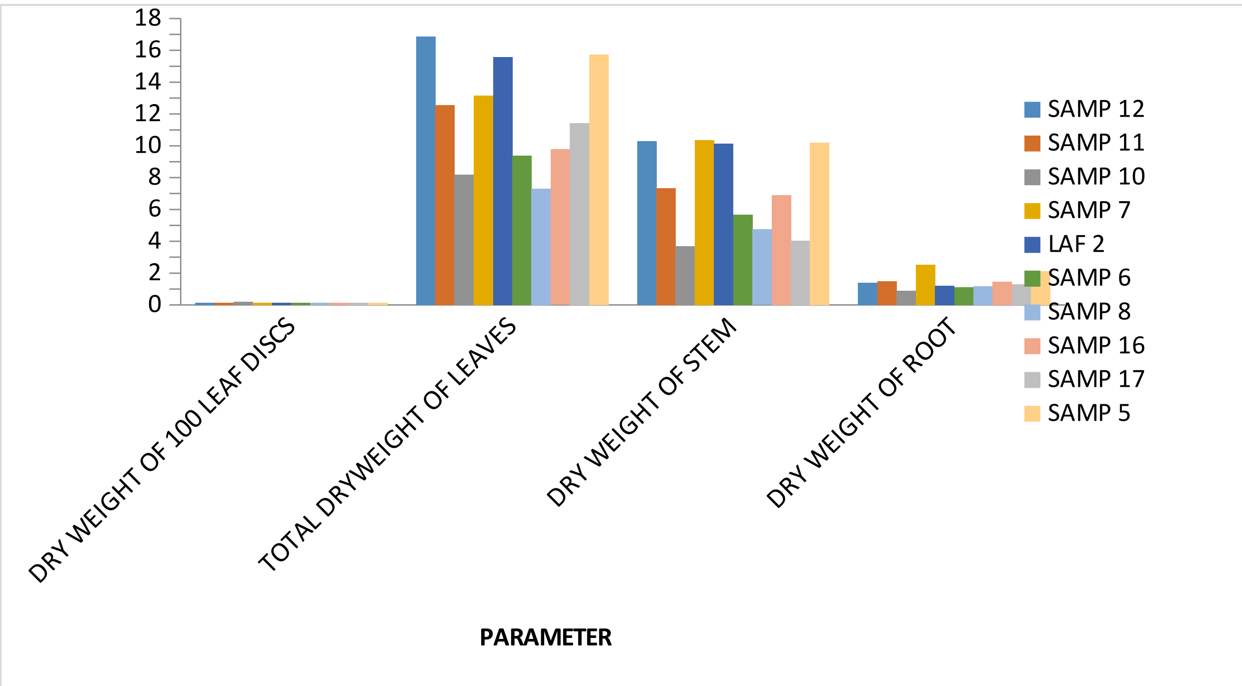

Fig. 1. Effect of varieties.

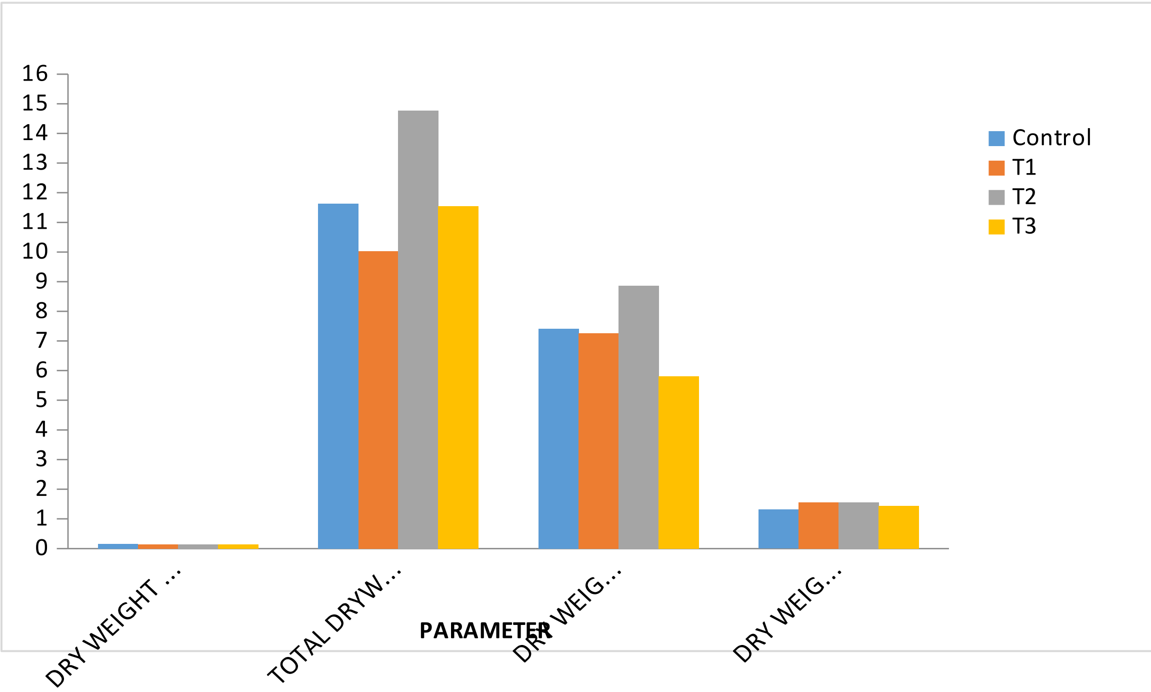

Fig. 2. Effect of treatment.

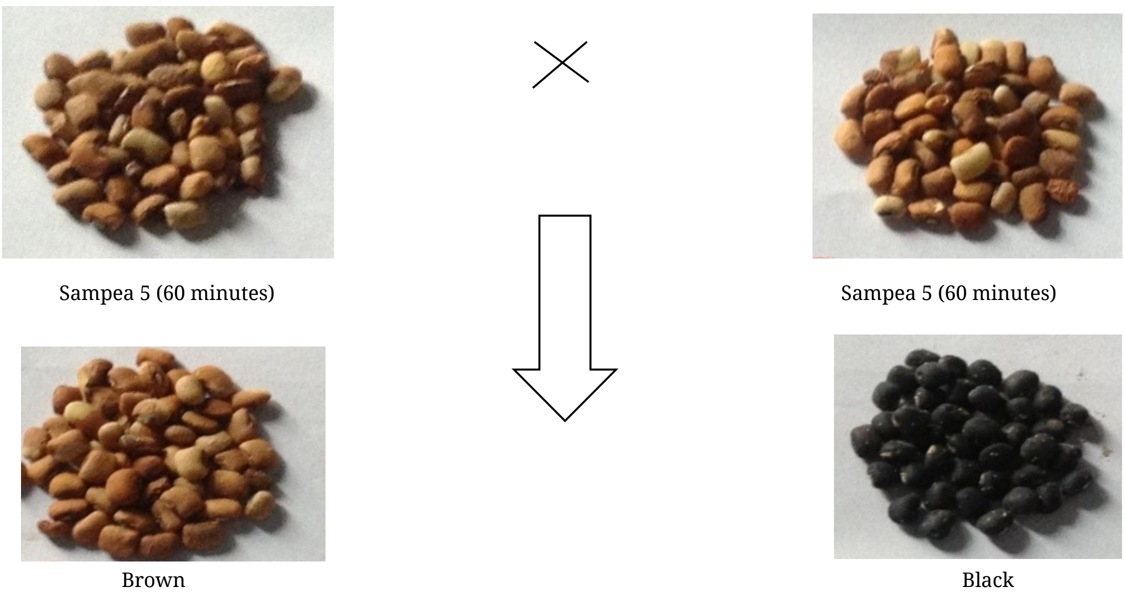

Fig. 3. Seed colour variability in cowpea exposed to alpha nanoparticles.

min period of time to alpha spin nanoparticle for improved performance (42).

The results of these finding have shown that application of Nanotechnology can bring about improvement as well as confront the different challenges facing the production of cowpea. Recent advances, manipulations, significant promising potentials and active uptake of necessary ingredients by nanoparticles confirmed the work of other researchers who confirmed that the product is effective in plant growth and development due to their very small size, reactivity and efficient penetration ability which may trigger a set of physiological processes affecting plant growth, crop yield and productivity.

The currently available information on the uses of nanotechnology will brighten the future prospects' and enhance our knowledge with a drastic reduction in the cost of pesticides and fertilizer. This approach can represent an important alternative that may accelerate production of varieties with useful trait and when applied alongside with conventional breeding will complement the efforts of breeders in overcoming challenges of cowpea production.

Although the implementation of nanotechnology for agriculture sustainability via enhancing yield and biomass is at the juvenile stage. The world will witness exceptional and unparalleled prospective of the nanoparticle. There is need to know the type of nano particle, size, concentration and mode of application so as to enable its application on large scale for crop improvement.

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Table 9. Morphological characteristics of the cowpea seed genotypes

Sl. No	Genotypes	Characteristic
1.	SAMPEA 12	Large brown seeds, Indeterminate, medium sized leaves
2.	SAMPEA 11	Larger white seeded, Indeterminate
3.	SAMPEA 10	Early maturing, larger white seeded, semi-erect
4.	SAMPEA 7	Determinate, seeds medium size, brown, larger leave size
5.	SAMPEA 6	Indeterminate, larger white seeds
6.	SAMPEA 8	Extra-early maturity, white seeded
7.	SAMPEA 16	Early maturity, drought tolerance, semi- erect
8.	SAMPEA 7	Early maturity, drought tolerance, erect
9.	SAMPEA 5	Semi-erect, brown seeds, drought tolerance

Authors' contributions

KEH drafted the article and supervised it critically for important intellectual content and also gave the final approval of the version to be submitted. KHA contributed to the conception of the design, collection of data from the field, oven drying of plants in the laboratory and also interpreted the analysed data. All authors read and approved the final manuscript.

Conflict of interests

Authors do not have any conflict of interests.

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