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EFFECT OF INTERACTION BETWEEN SEED SIZE AND SOWING DEPH OF CASHEW *ANACARDIUM OCCIDENTALE* (L) ON SEEDLINGS EMERGENCE AND HEIGHT UNDER TREATMENT WITH ORGANIC AND INORGANIC FERTILIZER IN GIDAN-WAYA, SOUTHERN GUINEA SAVANNA, NIGERIA

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ABSTRACT
An experiment to investigate the effect of interaction between seed size and sowing depth of cashew (*Anacardiumoccidentale (L))* on seedlings emergence and height under treatment with organic and inorganic fertilizer was conducted between April and July, 2010. The variables are seed sizes: 0.9cm^3, 1.5cm^3, 2.2cm^3; sowing depths: 3cm, 5cm and 10cm and fertilizer types: organic manure (cow dung) and inorganic fertilizer (N:P:K/15:15:15). There were significant interactions between the variables of seeds size and sowing depth ($P<0.05$); seed size and fertilizer (organic and inorganic) ($P<0.05$); sowing depth and fertilizer ($P<0.05$) and between seed size, sowing depth and fertilizer ($P<0.01$). Furthermore, there were significant interactions on the parameter of days to seedling emergence between small seed size and 5cm sowing depth, small and medium seed sizes and cow dung and between 5cm sowing depth and cow dung with fewer number of days to seedling emergence, while on seedling height, the interaction was between the variables of seed size and fertilizer and there was significant difference at 2, 6 and 12WAE. There were therefore, different levels of significance between the interacting parameters and some statistical similarities on seedlings height.

Keywords: Seed sizes, Sowing depth, Fertilizer types, Cashew.

INTRODUCTION
The cashew is a native of Brazil; from there the seed spread to other parts of tropical south and Central America, Mexico and the West Indies (John, 1973). It was introduced in Nigeria in the 17th century but large scale planting started in 1953 (Akinwale and Esan, 1989). However, cashew cultivation has spread to Western, Eastern and Northern states of Nigeria (Ayodele et al, 2001). Its generic name is Anacardium while its specific name is occidentale, the authority is Linnaeus.
The cashew plant is dicotyledous and undertakes epigeal kind of germination (Idodd-Umeh, 1996) a jungle or semi-jungle tree by nature (Fagbemi and Oshodi, 1991). It is a tropical evergreen tree and resistant to drought. The fruits are sweet to taste when it is ripe, but could have a biting characteristic taste when it is not ripe. It grows up to 12metres high and has a symmetrical spread of up to approximately 25metres. It is usually grown from seeds, seed nut should be thoroughly dry, clean and free from insect or fungal attack to enhance its growth capacity and efficiency.
Seeds are planted in the soil at reasonable depth and have the potential of growing when placed on the surface of the soil. Germination usually takes place in about 15-20 days when the seeds have absorbed water (Azam-Ali and Judge, 2004). Garner (1976) stated a general gardener's rule advocating the sowing of seeds at depth approximating to 2-3 times the diameter of the seed concerned.
Nigeria was ranked third after India ahead of Brazil with the world percentage production rate of 10 percentage (http:// www.uga.edu/fruit/cashew/html). Aremu et al (2006) reported that about 5000-7000 tones are produced annually and mainly as export crop.
Cashew nut is the most versatile of all nuts. The kernels are roasted and salted and eaten as food and also sold covered in chocolate for money (www.wikipedia.org/wiki/cashew). Preparation of jam and preserves from pulp(Ogunmoyela, 1983). Aderiye et al (1992) reported the use of cashew pomace for cake and chin-chin production and fermentation of cashew into wine. Aderiye and Mbadiwe (1993) reported an evaluation of alcoholic drink from cashew biomass extract. Village processing, roasting, soaking, sprouting and fermentation are reported to be effective in reducing mycotoxin and chemical toxin in plant foods (Njapu et al., 1998). The testa of the kernel is rich in tannins and hence mainly use in leather industry, it is also use as poultry feeds. The nut shell liquid extracted from hard shell is a versatile industrial raw material being use in preparing resins, vanishes, paints, plastics, insecticides, brake linings and wood preservatives. Anacardic acid is use for resins, coatings and functional materials. The bark is scrapped and soaked overnight or boiled as an anti-diarrheal. Seeds are ground up into powders and used topically as an antifungal and for healing cracked heel (www.wikipedia.org/wiki/cashew). Aremu et al (2006) reported on compositional studies and psychochemical characteristics of cashew nut flower.
Its' nuts can be use in cheese while young leaves are often eaten as salad in Malaysia. The pseudo fruit is mashed and mixed with water and sugar and used to make "feni" (a popular liquor) by

fermentation in Goa, India, likewise in the Southern Mtwara, Tanzania and Mozambique use the pseudo fruit to make liquor too, refer to as "bibo" in Kiswahili and "arguaardente" respectively (www.wikipedia.org/wiki/cashew)

Anon (1979) advocated for exploitation of plant protein as against the dependence on animal proteins because of economic recession which makes it almost impossible for the common man on the street to have access. Aluko and yada (1995); Shedrack and Oyebiodun (1999) reported that the ultimate success of utilizing plant protein as ingredients depend largely upon the beneficial qualities they impact to foods, which depends largely on their functions. Cashew kernel has 21% protein content and 60-75g calorie (Bola, 2002).

In justifying this research, Oyewole and Koffa (2010) reported sowing depth of cashew at 4-5cm, and soaking in water to hasten germination. Amoah (2005) also observed that cashew seeds soaked in water for 24 hours and sown in 4cm rather than 8-12cm depth gave better germination and early growth than cracked seeds. Joley and Opitz (1971); Ibikunle and Komolafe (1973) reported that imbibed seeds nut promotes early seed germination and increase the proportion when soaked in water for 24-48 hours. This research therefore undertook to find out the level of significant interaction among the variables of fertilizer (organic and inorganic), seed size and sowing depth, even at 10cm against recommended depth of 5cm (Azam-Ali and Judge, 2004); 4-5cm sowing depth (Oyewole and Koffa, 2010); 4cm (Amoah, 2005). Although the general gardener's rule according to Garner (1976) recommended sowing depth of a seed at approximately 2-3 times the diameter of the seed concerned and also the effect of the different interactions on seedling emergence and height. The quality of seeds and their sizes also determine how early seeds could emerge, with emergence taken to have occurred once plumule attains a height of at least 1cm above the surface of the soil (Ibukunle, 1975) and to also determine if there is no significant variation between the fertilizer nutrients used on seedling emergence and height.

In consideration of the many uses of Cashew, ranging from nutritional, medicinal values to industrial uses derived from its kernel, leaves, shell (oil), roots and branches, there is the need for a better method of cultivation as main objective, through understanding of the effect of interaction between and among the variables of seed sizes, sowing depths and fertilizer types so as to develop strategy for better approach to cultivation and sustained benefits.The cashew is a native of Brazil; from there the seed spread to other parts of tropical south and Central America, Mexico and the West Indies (John, 1973). It was introduced in Nigeria in the 17th century but large scale planting started in 1953 (Akinwale and Esan, 1989). However, cashew cultivation has spread to Western, Eastern and Northern states of Nigeria (Ayodele et al, 2001). Its generic name is Anacardium while its specific name is occidentale, the authority is Linnaeus.

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MATERIALS AND METHOD

Experimental Site

Field experiments were conducted between April and July, 2010 to investigate the effect of interactions between seed size and sowing depth on days to emergence and increase in seedlings height of cashew Anacardiumoccidentale under treatment with organic and inorganic fertilizer. The experiment was conducted at an agricultural farm located in Gidan-Waya, Jema'a Local Government Area, Kaduna State, southern guinea savanna ecology, Nigeria at an altitude of between 700-900m above sea level, longitude 9.280E and latitude 8.230N. The average amount of rainfall recorded within the period was 333.75mm.

Sources of Materials

Cashew seeds and fertilizer (N.P.K/15:15:15) used where purchased from seeds and fertilizer stores in Keffi main market in Nasarawa State respectively, while the organic fertilizer was obtained from a cattle range in Gidan-Waya, Jema'a L.G.A., Kaduna State.

Determination of Cashew Size

Each of the three different sizes of cashew seed was dropped into a measuring cylinder of 1000cm3 calibration at a time after it was filled with water to 50cm3 as initial volume displayed, three seeds of the same visually categorized sized seeds were dropped each at a time, and the new volume displayed was recorded, and the average determined which formed the size of cashew seeds. This was repeated for all other categorized seeds. The average of each cashew seed determined from the volume size of the cashew seeds are thus; large seed size measured 2.2cm3, medium size 1.5cm3 and small size 0.9cm3)

Viability Test and Pre-seeding Treatment of Seeds

All the 108 categorized seeds for the various sizes were water tested to determine their viability. Azam-Ali and Judge's (2004) method of seed viability test was used which proved that those that sank were viable and so were selected and retained as against those that floated which was an indication of in-viability and were discarded. The selected seeds were soaked in normal tap water for 48 hours to soften the seed coat for hastened growth (Azam-Ali and Judge, 2004)

Experimental Design

The three sizes of cashew seeds used were 0.9cm3, 1.5cm3 and 2.2cm3 represented as small, medium and large respectively. These categorized seeds were planted at three different sowing depths (D1=3cm, D2=5cm and D3=10cm). Nutrients (cow dung and N.P.K/15:15:15) were applied as required (N1-organic fertilizer of cow dung, N2-inorganic fertilizer of N.P.K/15:15:15) for all categories of seed sizes of cashew.

All these gave 18 treatment combinations and were replicated three times. The experiment was laid in a randomized complete block design (RCBD)

Cashew Seeds Planting Procedure

The procedure involved in this research was such that the two variables of sowing depth and nutrients were the factors that determined its effects on the plant. The planting procedures include the following steps:

i. Fifty four dark coloured nursery polythene bags, (26.5cm by 21cm in length and width) arranged in 18 treatment combinations and replicated three times were half-filled with top soil obtained from the research farm.
ii. The top soil in the bags were half mixed with either cow dung or N.P.K (15:15:15) designated as F1 and F2 respectively.
iii. The treatments (polythene bags) were watered daily for six days before planting of cashew seeds were done.
iv. The sowing depths were determined by the use of already measured and cut out sticks.
v. Two seeds of the same size were planted per treatment combination and the experimental design.

Weeds were regularly removed from the polythene bags and surroundings by hand to avoid competition for nutrients available to the plant, regular and adequate irrigation was carried out by the use of watering can prior to the unset of the rains.

Field Observations and Data Collection

The planted seeds were kept under close monitoring for seed emergence which is when plumule attains a height of 1cm above soil surface (Ibukunle, 1975). The parameters measured are number of days to emergence; these were the number of days between planting and emergence of seedlings and, increase in seedling height which was determined by using meter rule (cm) to measure the height from soil level to the tip of shoot after full emergence and at two weeks interval for 12 weeks after emergence.

Analysis of Data

Data collected were subjected to analysis of variance to test for the treatment effects for significance using F-test as described by Snedecor and Cochram (1982). Significance of mean difference was tested using the modified Duncan's Multiple Range Test (DMRT) (Duncan, 1995).

RESULTS

There were significant interactions between the variables of seed size and sowing depth (P<0.05); seed size and fertilizer (organic and inorganic) (P<0.05); sowing depth and fertilizer (organic and inorganic) (P<0.05) and between seed size, sowing depth and fertilizer (organic and inorganic) (P<0.01) (table 1)

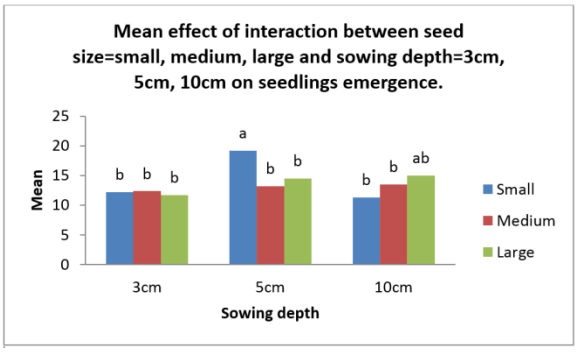
Table 1: Effect and interactions between seed size and sowing depth of cashew seeds Anacardiumoccidentale on seedlings emergence and height under treatment with organic and inorganic fertilizer.

	Count on Mean Number of Days to Emergence DTE
Seed Size (SS)	
Small (S1)	42.67
Medium (S2)	39
Large (S3)	41.17
F-Ratio	NS
DMRT	-
Sowing Depth (SD)	
3cm (D1)	108.5c
5cm (D2)	140.5a
10cm (D3)	119.5b
F-Ratio	*
DMRT	6.06
Fertilizers (F)	
Cow-dung (F1)	138a
NPK (F2)	107.7b
F-Ratio	**
DMRT	5.77
Interactions	
SS×SD	*
SS×F	*
SD×F	*
SS×SD×F	**

2=Mean followed by different letters within the same column and treatment are significant at 5% level of probability using DMRT
*- significant at 0.05 probability level
**- Significant at 0.01 probability level
NS- Not significant at 0.05 probability level
DTE-Days to emergence

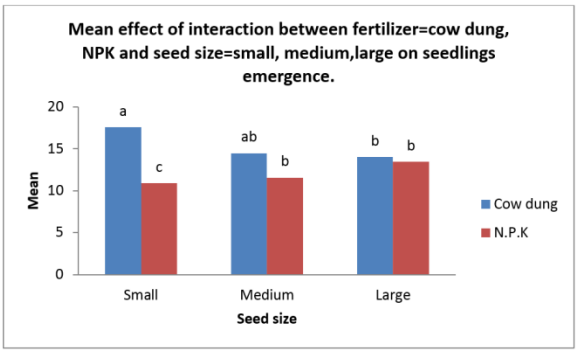
Table 2 shows that interaction between 5cm sowing depth and small seed size was significantly higher, indicating that the seeds sown in 5cm depth emerged earliest having the lowest number of days, with similar effect in the interaction between 10cm sowing depth and large seed size, while all other interactions were same with the later interaction but not significantly different from each other. Similarly, the interaction between small seed size and cow dung was significantly higher than all other interactions although similar with medium seed size and cow dung as shown in table 3. In table 4, the interaction between 5cm sowing depth and cow dung was significantly higher than all other interactions, followed by interaction of 10cm sowing depth and cow dung. All other interactions were not significantly different from each other.
Significant interactions occurred at three stages for seed size and fertilizer and at many stages for seed size, sowing depth and fertilizer as shown in table 5 for increase on seedling height of plant.

Table 2: Effect of interaction between seed size and sowing depth of Cashew *A. occidentale* on seedlings emergence under treatment with organic and inorganic fertilizer.



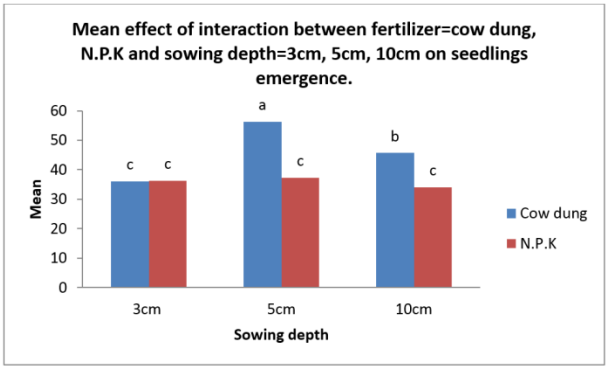
2. Means followed by the same letters within the same column are significantly different at 5% level of probability using DMRT.

Table 3: Effect of interaction between seed size of cashew *A. occidentale* and fertilizer on seedlings emergence under treatment with organic and inorganic fertilizer.



2. Means followed by the same letters within the same column are not significantly different at 5% level of probability.

Table 4: Effect of interaction between sowing depth of Cashew *A. occidentale* and fertilizer on seedlings emergence under treatment with organic and inorganic fertilizer.



2. Means followed by the same letters within the same column are not significantly different at 5% level of probability.

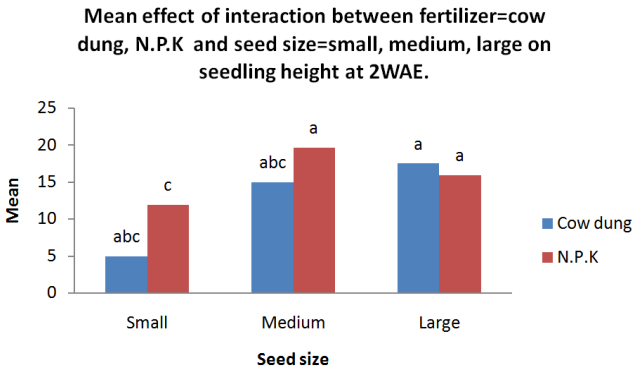
Table 5: Effects and interactions between seed size and sowing depth of Cashew *A. occidentale* on seedling height under treatment with organic and inorganic fertilizer at 2, 4, 6,8,10 and 12 WAE.

	Count on Mean Seedlings Height (cm) at 2-Week Intervals					
	2WAE	4WAE	6WAE	8WAE	10WAE	12WAE
Seed Size (SS)						
Small (S1)	40.43b	56.10b	66.72b	79.87	86.65	92.75
Medium (S2)	52.02a	69.35a	84.32a	96.05	105.7	113.4
Large (S3)	50.33a	74.35a	86.17a	99.87	106.2	108.6
F-Ratio	*	*	*	NS	NS	NS
DMRT	6.96	14.79	12.17	-	-	-
Sowing Depth (SD)						
3cm (D1)	51.0	77.11	85.48	98.67	107.2	115.7
5cm (D2)	44.32	64.95	75.42	85.82	94.22	96.13
10cm (D3)	47.47	65.23	76.3	91.30	97.17	102.92
F-Ratio	NS	NS	NS	NS	NS	NS
DMRT	-	-	-	-	-	-
Fertilizers (F)						
Cow dung (F1)	71.22	108.25	123.9	144.05	153.95	162.2
NPK (F2)	71.57	99.05	113.3	131.7	44.62	152.6
F-Ratio	NS	NS	NS	NS	NS	NS
DMRT	-	-	-	-	-	-
Interactions						
SS×SD	NS	NS	NS	NS	NS	NS
SS×F	*	NS	*	NS	NS	*
SD×F	NS	NS	NS	NS	NS	NS
SS×SD×F	*	NS	*	*	*	*

1=WAE (Weeks after emergence)
2= for main treatment effects, mean followed by the same letters within the same column and treatment are not significant at 5% level of probability using DMRT
*- significant at 0.05 probability level
NS- Not significant at 0.05 probability level

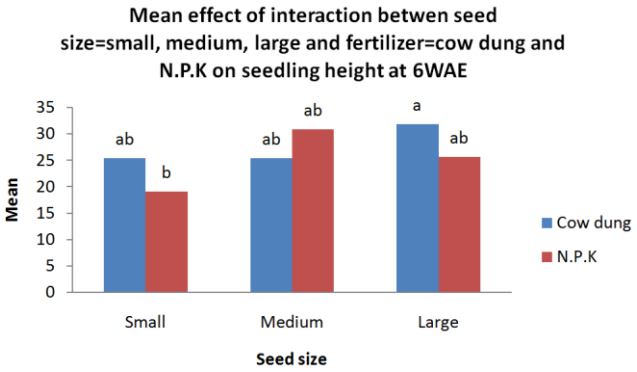
Tables 6, 7 and 8 shows further the effect of interactions.
Table 6 shows no significant difference among the interactions between medium seed size and N.P.K, large seed size and cow dung, large seed size and N.P.K but with significantly higher seedling height than other interactions although with similar seedlings height. Large seed size and cow dung was statistically higher than all other interactions with significant difference, while small seed size and N.P.K had lowest height statistically and significantly but not different from some other interactions at 6WAE in seedling height as shown in table 7. In table 8, the interactions between large and medium seed sizes with cow dung and N.P.K fertilizers respectively were not significantly different from each other on seedlings height at 12WAE but higher than others.

Table 6: Effect of interaction between seed size and fertilizer on seedlings height of Cashew *A.occidentale* under treatment with organic and inorganic fertilizer at 2WAE



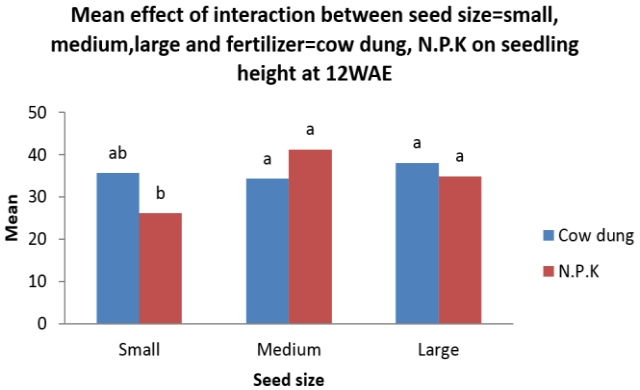
2. Means followed by the same letter within the same column are not significantly different at 5% level of probability using DMRT.

Table 7: Effect of interaction between seed size and fertilizer on seedlings height of Cashew*A.occidentale*at 6WAE



2. Means followed by the same letter within the same column are not significantly different at 5% level of probability using DMRT

Table 8: Effect of interaction between seed size and fertilizer on seedling height of Cashew *A. occidentale* at 12WAE



2. Mean followed by the same letter within the same column are not significantly different at 5% level of probability using DMRT

DISCUSSION AND CONCLUSION

There were significant differences on days to emergence of seedlings at various levels of interaction between the different parameters in the variables showing earliest emergence of seedlings with similarities and non-significant differences in some interactions. Small size seed and 5cm sowing depth = Large seed size and 10cm sowing depth emerged earliest. Small size seeds and cow dung emerged earliest too and similar with medium seed size and cow dung interaction while others were similar with the later and, the interaction of 5cm sowing depth and cow dung was significant as well with 10cm and cow dung next, while others interacted with no difference from each other. The differences observed on the rates of emergence as affected by the different interactions on the variables of either seed size, sowing depth or fertilizer could be as a result of interruption by one factor or the other to such an extent that emergence rate would either slow or rise, since it was observed that sowing depths, seed sizes were not within exceeded limit, except interaction with fertilizer types (organic and inorganic). Various interactions with cow dung showed significant seedlings emergence against N.P.K/15:15:15 fertilizer. These variations could be due to some environmental factors such as temperature, water, pH, light and oxygen as well as physiological factors. Siddig and Abdellatif (2015) reported that the different size of seeds have different levels of starch and other food storage which may be one factor that influences the expression of number of germinated seeds in faba bean but**,** it was observed that seed sizes of cashew were within good range since there were significant interactions at various levels. This agrees with the findings of Girish *et al*., (2001) and; Indira *et al*., (2000) who reported that seed size is a considerable and significant factor in the germination and early stage of plant growth. Aikins *et al.,* (2006) also stated that interaction between seed size and depth of planting greatly reduced the number of germinated seeds with increased depth of planting, deep sowing can also significantly reduce crop emergence and yield.

Germination percentage was found to reduce from 80.0 percent at 5cm planting depth to 78.9 percent at the 10cm in Faba beans (Siddig and Abdellatif 2015). Similarly, Hojjat (2011) reported that the germination parameters were significantly related by seed weight and, large seeds germinated early and showed better germination than small seeds of lentil genotypes. Germination percentage and seed vigor are in concurrence with findings of Roozrokh *et al*., (2005) on chick pea, Salih and Salih (1981) on Faba Bean and Roshanak (2013) on soybean. The negative effect of deep sowing depth was reported by Nabi *et al*., (2011) who found that seedling emergence was decreased with increased sowing depth in cotton. The deeper the seed is sown the more strength it needs to push its shoots above the soil surface. It is suggested that with similar seeds, shallow sowing depth are best. Supporting evidences were also reported by Singh *et al*., (1972) in Soybean.

Stickler and Wassom (1963) reported a similar interaction of seed size and planting depth with birds foot trefoil. It was also reported that germination of bush beans was not affected by seed size or planting depth. Likewise, germination of lima beans (Wester and Magruder, 1958) has been reported to be little affected by seed size.

Work by Rotunno (1924) indicates that varieties of the same crop may respond differently. He found that in some varieties of radish, highest germination percentages occurred with large seed, in others the medium, and in still others, the small seed.

These findings shows that seed sizes; small, medium and large were generally viable because of its high density, while sowing depths of 3cm, 5cm and 10cm are not within exceeded sowing depth and the two fertilizers were also good, but cow dung an organic fertilizer performed better throughout the period of experiment though with no significant differences except on days to emergence of seedlings.

Interaction of the various parameters between the variables of seed size and sowing depth, sowing depth and fertilizer on seedlings height showed various significant height differences at 2WAE, Large seed size and cow dung=Large seed size and N.P.K., Medium seed size and N.P.K., had similar higher height but not different from each other. At 6WAE, Large seed size and cow dung grew higher than others but small seed size and N.P.K fertilizer was lowest, although with similar height like others in the interaction. At the 12WAE, Large seed size and cow dung=Large seed size and N.P.K=Medium seed size and cow dung=Medium seed size and N.P.K were not different from each other but had higher seedlings height. This agrees with Azam-Ali and Judge (2004) report that the sowing depths are not within exceeded limit for cashew. While the depth was not beyond utilization reach for fertilizer, since the soil was half mixed with it before planting commenced. Interaction of seed size and organic and inorganic fertilizers showed alternate significance throughout the period of growth. Kalton *et al*., (1959) and Erickson (1946) also found that small seed resulted in more decreased vigor than large seeds with increased depth of planting. This suggests that the plant is entirely dependent for survival on the initial food stored for early growth until the plant starts producing its own food. Poor performance of small seeds at deep depth may be attributed to an exhaustion of reserve food supply as emergence is accomplished. In the end, the seed sizes and sowing depths were not within exceeded range on seedling emergence with various degrees of significance in the interactions, except that cow dung interacted better, while on seedling height which was basically an interaction between seed size and fertilizer, there were various degrees of interaction with significances implying that all fertilizers, cow dung and N.P.K performed well on height.

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