

Original Research Article

Title: Effects of nut weight and sowing depth on emergence and growth of cashew

(*Anacardium occidentale* L.) seedlings.

ABSTRACT

An experiment was carried out at the nursery of the Cocoa Research Institute of Ghana, Tafo, to determine the influence of nut weight and depth of sowing on the emergence and vigour of cashew seedlings. The factorial experiment was laid out in a split plot with four **replications**. Nut weight and depth of sowing served as the main and sub-plots respectively. Data collected included percent final emergence, stomatal conductance, transpiration rate, leaf chlorophyll content, leaf chlorophyll fluorescence (fv / fm), rate of photosynthesis, seedling height, stem diameter and dry matter accumulation. The results showed that seedlings generated from nuts weighing over 8 g were more vigorous, ranking high on physiological parameters such as stomatal conductance, photosynthesis at the leaf level and dry matter accumulation, and morphological parameters such as height and stem diameter gain. Cashew nuts sown at the 2 cm depth gave superior emergence although dry matter accumulation after three months was unaffected by sowing depth. It was therefore concluded that nuts weighing 8 g be sown at 2 cm depth for raising cashew seedlings to be used as root stock.

Key words: Sowing depth, nut weight, chlorophyll fluorescence, stem diameter.

1. INTRODUCTION

Cashew (*Anacardium occidentale*, L.) belongs to the family *Anacardiaceae*, whose members are known to have resinous barks and often, caustic oils in leaves, barks and fruits. It consists of 73 genera and 600 species in tropical and subtropical regions [10].

Cashew is a recent introduction to the agricultural production systems of West Africa. In Ghana, commercial cashew cultivation which started a few decades ago uses nursery-raised seedlings. This often results in high mortality of the transplants, even in conditions considered suitable for successful establishment of cashew, leading to the conclusion that cashew does not transplant well into the field [2, 12].

The selection of seedlings for transplanting into the field is based on the morphological features [3, 11, 12]. The physiological processes taking place in most young plants yet to develop efficient leaf and root systems however may depend partly on the initial seed weight which has implications on the availability of stored carbohydrates that can be utilized for early growth. In the case of cashew, nut weight has been reported to have significant influence on the morphological growth performance of the seedlings in the nursery leading to the recommendation of bigger nuts for raising seedlings [1, 4]. Research work [9] with different nut weights concluded that cashew seedlings raised from nuts weighing more than 16 g in the nursery resulted in superior leaf area indices, higher growth rates and dry matter production.

Sowing depth on the other hand has been reported to be a key factor determining germination (or emergence) percentage and speed [15] as well as subsequent seedling growth performance [5, 17]. Other researchers [17], working with shea seeds attributed better emergence and growth to seed size and concluded that sowing depths giving better emergence also showed better seedling growth. They therefore concluded that smaller seeds could be planted at 2-8 cm depths while larger ones are planted at 4 - 8 cm depth. In most instances where cashew nut weight has been studied, no mention has been made of the suitable sowing depth [3, 4, 9, 12] although it is well established in research that seed size or weight has a profound influence on the ability of the plumule to emerge from the soil [7, 14]. Whereas 3-5 cm was recommended by MOFA for direct seeding, the recommendation did not take into account nut weight [6]. Also, no additional recommendations were made with regard to nut weight and sowing depth for raising seedlings in the nursery. The objective of this experiment therefore was to determine the suitable nut weight for cashew genotypes available in Ghana and sowing depth for the generation of vigorous cashew seedlings in the nursery.

2. MATERIALS AND METHODS

2.1 Experimental design and treatments

The experiment was conducted at the main nursery of the Cocoa Research Institute (latitude 6° 13' N, longitude 0° 22' W, altitude 222m above sea level) of Ghana in 2012. The experiment was laid out in a split plot with 4 replications. Nut weight was used as main plot and sowing depth as subplot. Nursery bags (17.5 cm x 25 cm) containing 6 kg of top soil each and provided with drainage holes were used for the experiment. The

polybags were arranged under a shed allowing 40 % light penetration and thoroughly watered. Cashew nuts weighing < 6 g, 6-8 g and > 8 g were sown at 2 and 4 cm depths the following day at the rate of one seed per bag and the bags watered again. Subsequent watering was done every other day throughout the experiment.

2.2 Data collected

Data on the number of days for 50 % emergence was recorded. The number of seedlings that emerged per treatment was counted three weeks after sowing. Percent final emergence was then determined following the procedure described in earlier study [17].

Thus;

$$E (\%) = \frac{TEs}{TSs} \times 100$$

Where:

E (%) - percent final emergence

TEs - total number of seeds emerged

TSs - total number of seeds sown

Twenty core plants were randomly selected and tagged for physiological and morphological data measurements. Data on leaf chlorophyll content (measured with a chlorophyll content meter - CL-01 by Hansatech Instruments Ltd), leaf chlorophyll fluorescence (measured with a leaf chlorophyll fluorometer - FP 100 by Photon System Instruments Ltd) and rate of photosynthesis at the leaf level (measured with a portable infra-red gas analyzer - LcPro, ADC Bioscientific, UK) were taken at monthly intervals from ten of the twenty core plants to determine how treatments affected chlorophyll

formation and photochemistry. Stomatal conductance and transpiration rates of ten core plants were also monitored monthly with an infra-red gas analyzer to determine how treatments affected carbon dioxide exchange.

To provide an estimate for morphological growth, stem diameter was measured 5 cm from the base of each of the twenty core plants. The average of the twenty measurements was then taken as the diameter of seedlings for each treatment. Heights of these same twenty plants were recorded using a standard metre rule and the average also determined as the representative height of each treatment.

Dry matter accumulation at three months was determined through destructive harvesting of twenty core plants. The harvested plant materials were first weighed (Fwt), oven dried at 80 °C for three days until a consistent weight was obtained. The weights of the dried samples (Dwt) were then taken as the dry matter produced by the seedlings. Dry matter accumulated per plant (DM_p) as a percentage of total plant biomass at harvest was then determined as:

$$DM_p (\%) = \frac{Dwt}{Fwt} \times 100$$

Where:

DM_p - average dry matter accumulated per plant (%)

Fwt - average fresh weight per plant

Dwt - average dry weight per plant

2.3 Data analysis

Data collected on transpiration, chlorophyll fluorescence, rate of photosynthesis at the leaf level, seedling height and girth, and dry matter production were analysed by

ANOVA and means compared using the least significant difference (Lsd) values. Data on percent emergence was arc-sine transformed before analysis.

3. RESULTS

3.1 Final emergence

There were no significant interactions between nut weight and sowing depth with respect to days for 50 % emergence (data not shown) and final emergence (Table 1). Also, nut weight did not significantly ($P<0.05$) influence percent final emergence. The percent final emergence of seeds sown at 4 cm was however significantly ($P<0.05$) reduced (Table 1).

3.2 Stomatal conductance, transpiration rate, chlorophyll fluorescence and photosynthetic rate

Neither nut weight nor sowing depth affected photosynthetic activity significantly (Figures 1, 2, 3 and 4). Both nut weight and sowing depth did not significantly influence ($P<0.05$) stomatal conductance of cashew seedlings from 1-3 months after sowing (Fig 1a and 1b). Transpiration rates of the seedlings in the first two months after sowing were also not significantly influenced ($P<0.05$) by both nut weight and sowing depth (Fig 2a and 2b). In the third month, seedlings from the > 8 g nuts recorded very high transpiration rates that were similar to the < 6 g seedlings but significantly higher ($P<0.05$) than the transpiration rates of the 6-8 g seedlings (Fig 2a). Also, nuts sown at 4 cm depth resulted in seedlings with significantly higher ($P<0.05$) transpiration rates

compared to seedlings from nuts sown at 2 cm depth (Fig 2b). There was a general decline in chlorophyll fluorescence from 1-3 months after sowing with regard to nut weight and sowing depth (Fig 3a and 3b). Differences between treatments were however not significant. The rate of photosynthesis of cashew seedlings was not significantly influenced ($P<0.05$) by nut weight **at** one month after sowing (Fig 4a). In the second month, the photosynthetic rate of the < 6 g and > 8 g seedlings were similar but both were significantly higher ($P<0.05$) than the rate of the 6-8 g seedlings (Fig 4a). Also, the photosynthetic rate of the < 6 g seedlings was significantly higher ($P<0.05$) than that of the 6-8 g seedlings **at** three months after sowing (Fig 4a). At the leaf level, sowing depth did not significantly ($P<0.05$) influence photosynthetic rates in cashew seedlings during the three months of growth (Fig 4b).

3.3 Seedling height and stem diameter

Seedling height (Fig 5a and 5b) and stem diameter (Fig 6a and 6b) showed linear increments throughout the three months of monitoring with regard to nut weight and sowing depth. Seedlings from the > 8 g seeds were significantly taller ($P<0.05$) than those of the < 6 and 6-8 g seeds throughout the three months of growth (Fig 5a). Height difference between seeds sown at 2 cm and those sown at 4 cm depth was also not significant ($P<0.05$) throughout the three months of growth (Fig 5b). There were no significant differences ($P<0.05$) in stem diameter of seedlings with regard to nut weight although seedlings from the > 8 g seeds recorded relatively bigger stem diameters throughout the three months of growth (Fig 6a). Cashew seeds sown at 2 cm depth recorded relatively bigger stem diameters although this was not significantly different ($P<0.05$) from the diameters of those sown at the 4 cm depth (Fig 6b).

3.4 Dry matter accumulation

There were also no significant interactions between nut weight and sowing depth with regard to the amount of dry matter accumulated per seedling at 1, 2 and 3 months after sowing (Table 1). Cashew seedlings from the > 8 g nuts however, accumulated dry matter that was significantly ($P < 0.05$) larger than the dry matter accumulated by the seedlings from the < 6 and 6-8 g nuts (Table 1). Sowing depth had no significant influence ($P < 0.05$) on dry matter accumulation of cashew seedling at 3 months after sowing although the values recorded was relatively high for seeds sown at the 2 cm depth (Table 1).

4. DISCUSSION

The lack of significant differences in days to 50 % and final emergence with regard to nut weight, and the difference observed with regard to depth of sowing confirms earlier reports [7; 14] which concluded that deeper sowing requires more stored energy to bring the plumule to the surface. The low emergence obtained from seeds sown at 4 cm was therefore probably as a result of relatively lower amounts of stored carbohydrates available to support the growth and emergence of the plumule from that depth. Similar results have been reported in earlier studies [17; 14]. Cashew seedlings did not show significant variations in their stomatal conductance probably because of the uniform environmental conditions provided in the nursery, supporting earlier findings [13]. This was probably because stomatal conductance was less dependent on the initial nut weight and sowing depth and more dependent on the seedling environment. Similar conclusions was made by other researchers [16] working with crops in the field. The

186 massive depressing of stomatal conductance in the second month (December) by both
187 nut weight and sowing depth was as a result of the dry conditions experienced during
188 that period which probably lowered water vapour pressure, thus prompting the
189 seedlings to reduce stomata opening and CO₂ exchange, confirming the earlier
190 conclusion that stomata conductance were more dependent on the environment by **this**
191 **and earlier studies** [13; 16]. Transpiration rate, which is closely linked to stomatal
192 conductance therefore showed similar pattern [13]. The rate of water loss through the
193 leaves of the seedlings was however heightened in the third month after sowing. The
194 increased rate at this stage was probably as a result of improved atmospheric
195 conditions that encouraged the plant to open its stomata for CO₂ exchange [13]. The
196 higher rate recorded by deep sown seeds at this stage could be attributed to better root
197 depth with access to potentially more moisture [16], thus allowing the seedlings to
198 maintain open stomata for CO₂ exchange since water loss could easily be replaced.

199 The similarities in leaf chlorophyll fluorescence regardless of nut weight and sowing
200 depth show that the chloroplast of the seedlings responded much in the same way to
201 photosynthetically active radiation (PAR). The general decline in leaf chlorophyll
202 fluorescence was therefore attributable to increased photosystem II (PSII) efficiency [8].
203 There was therefore a resultant corresponding increase in rate of photosynthesis of the
204 seedlings. This was expected as the seedlings had been observed to show higher
205 transpiration rates, potentially carrying out more CO₂ exchange that resulted in higher
206 rates of photosynthesis. Because the rate of photosynthesis, and hence seedling growth
207 did not vary with sowing depth, dry matter accumulation was thus unaffected by sowing
208 depth contrary to the conclusions **of other studies** [17]. It was however, realized that

long periods of CO₂ exchange and higher rates of photosynthesis in seedlings from the > 8 g nuts resulted in plants that were superior in height throughout the three months and stem diameter in the third month after sowing. This superior growth was probably as a result of early rapid development of photosynthetic leaf area supported by relatively large amount of stored carbohydrates in those large nuts. Therefore, dry matter production at three months was favoured by larger nut weight (> 8 g) and shallow sowing [9] which both encouraged higher rates of photosynthesis.

5. CONCLUSION

Based on the result of this study, it was concluded that larger cashew nuts (>8 g) sown at 2 cm depth will result in vigorous seedlings with a greater potential for successful grafting and survival in the field after the grafts are transplanted.

COMPETING INTERESTS

There are no competing interests

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application on emergence and growth of shea butter tree seedlings (*Vitellaria paradoxa* C. F. Gaertn.). African Journal of Biotechnology. 2010; 9(10), pp. 1443-1449.

Table 1 Effect of nut weight and sowing depth on percent final emergence and dry matter accumulation of three months old cashew seedlings.

Treatment	Percent final emergence (%)	Dry matter accumulation plant ⁻¹ at 3 months (g)	Dry matter accumulation plant ⁻¹ at 3 months (%)
Nut weight (g)			
< 6	70.2 (58.7)	85.8	28.5
6 – 8	69.0 (58.6)	80.5	36.3
> 8	67.0 (56.4)	119.8	31.3
Lsd _{0.05}	ns	18.2	ns
Sowing depth (cm)			
2	74.7 (62.4)	99.5	34.8
4	62.5 (52.8)	91.2	29.3
Lsd _{0.05}	4.3	ns	ns
CV (%)	38.2	17.9	21.5

Note: values in parenthesis are arc-sine transformations.

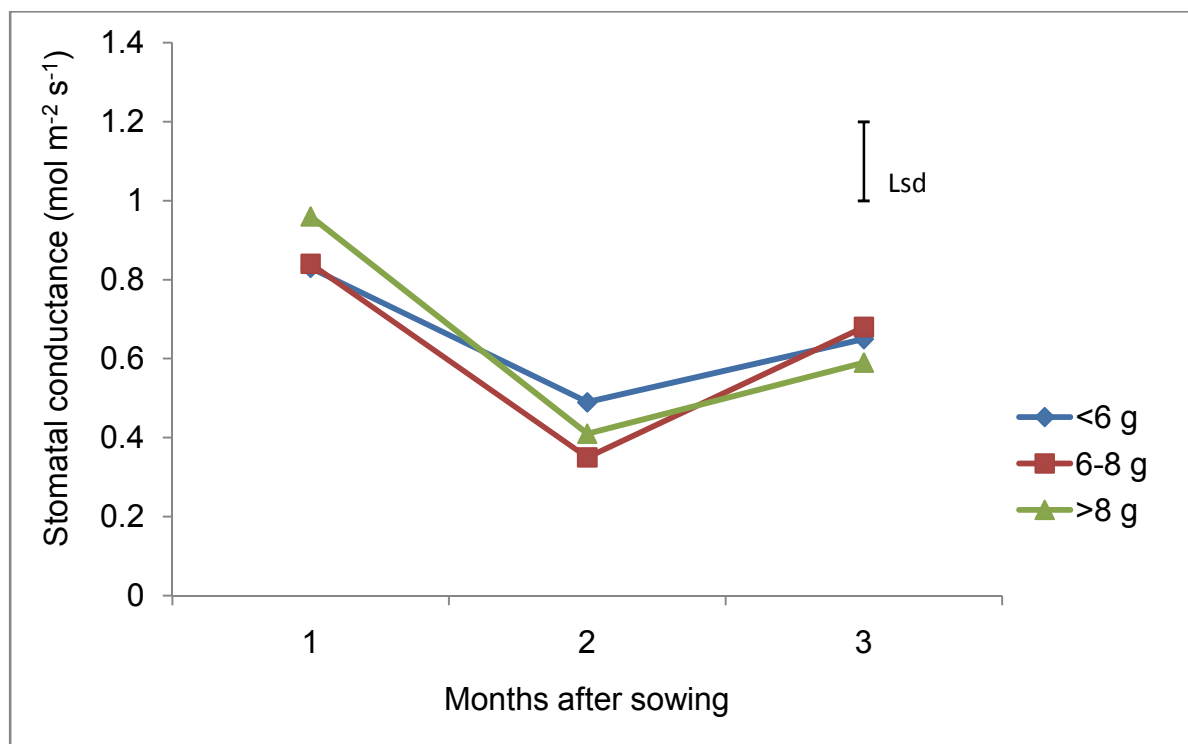


Fig 1a

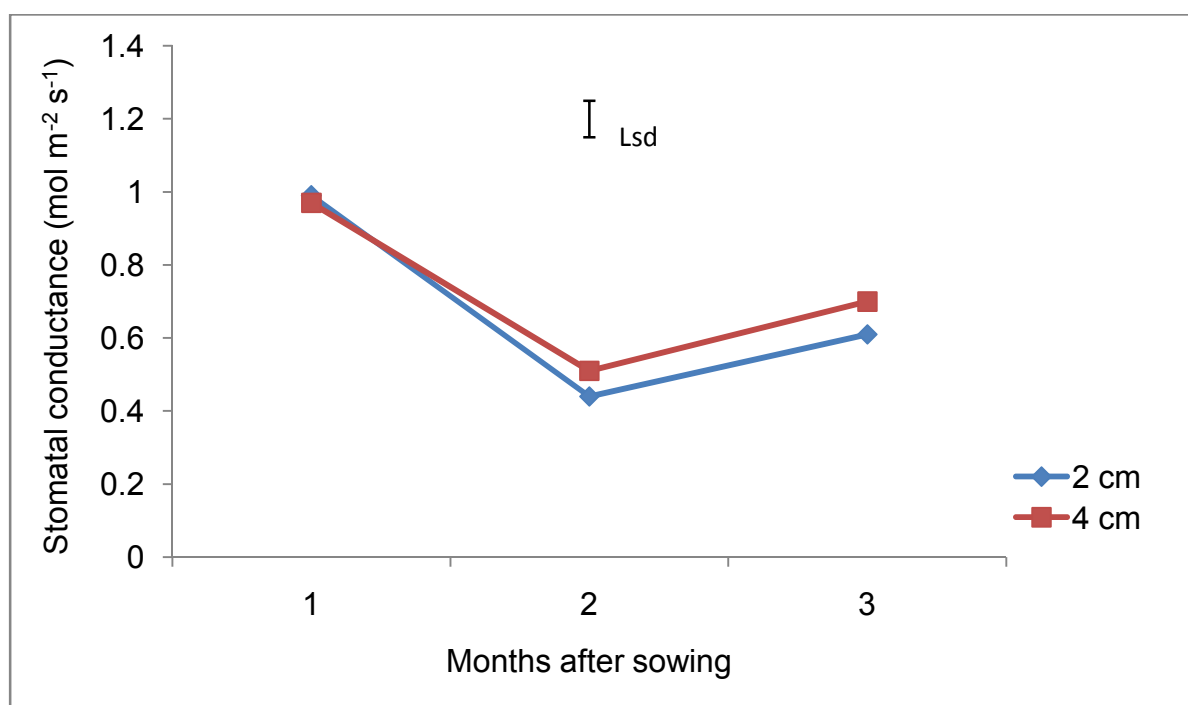


Fig 1b

Fig 1.1 Effects of nut weight (a) and sowing depth (b) on stomatal conductance of cashew seedlings at various times after sowing in the nursery.

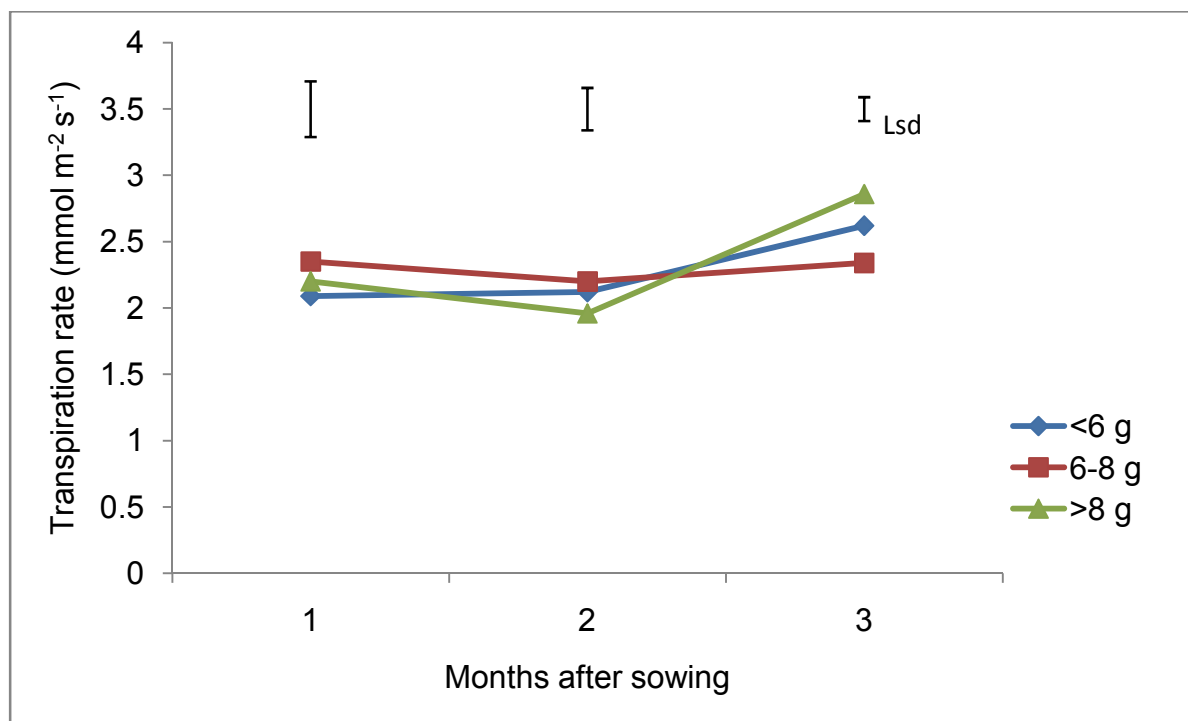


Fig 2a

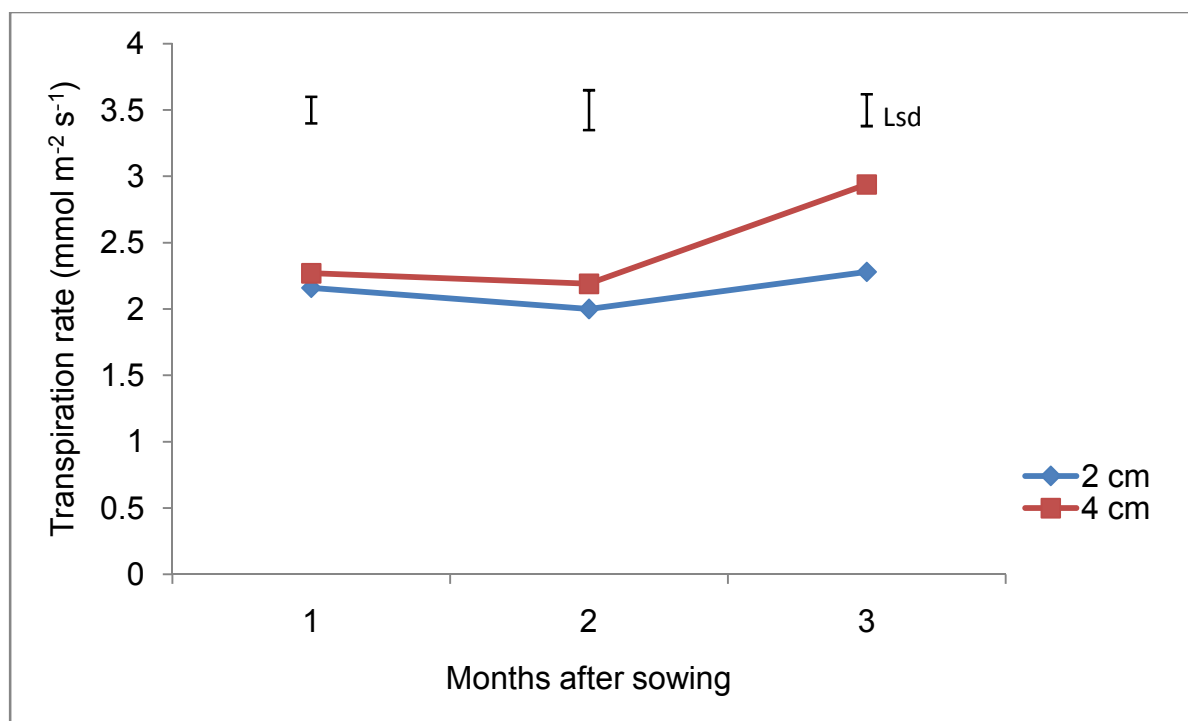


Fig 2b

Fig 1.2 Effects of nut weight (a) and sowing depth (b) on transpiration rates of cashew seedlings at various times after sowing in the nursery.

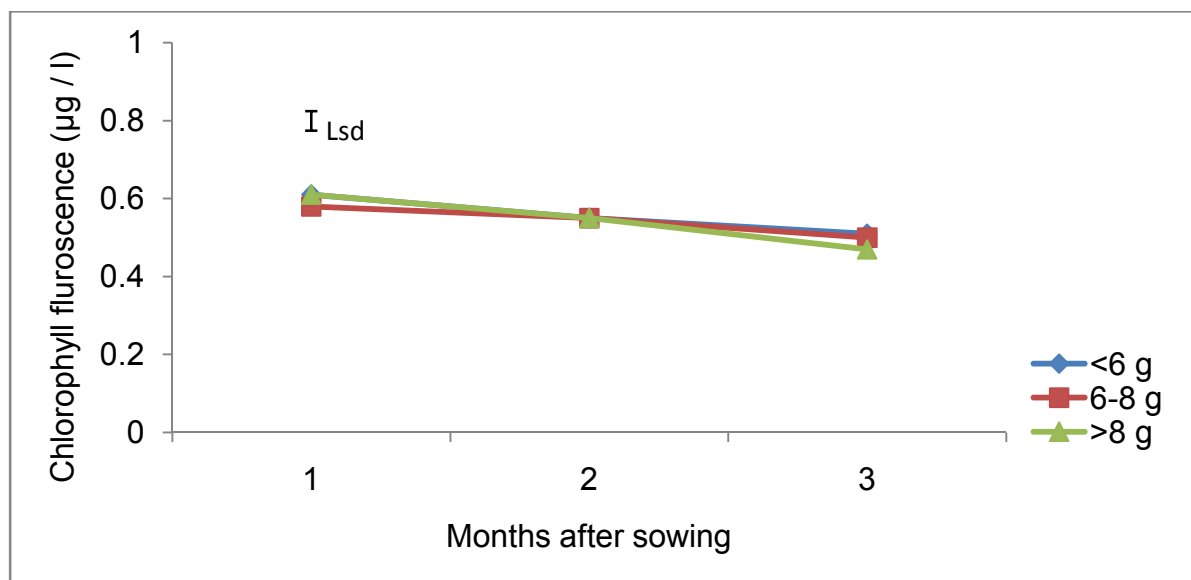


Fig 3a

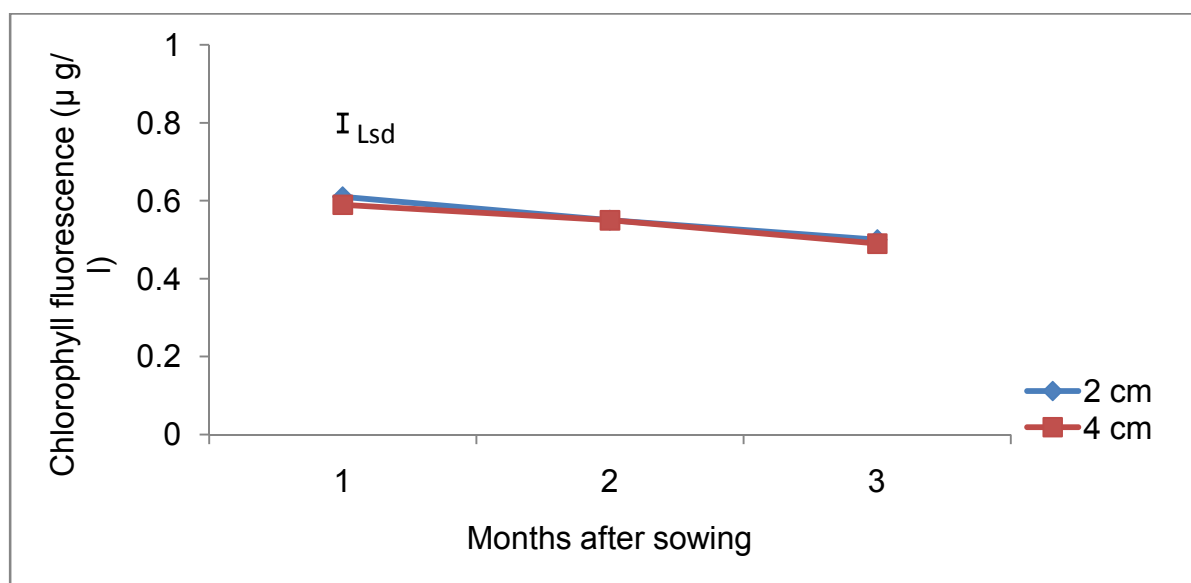
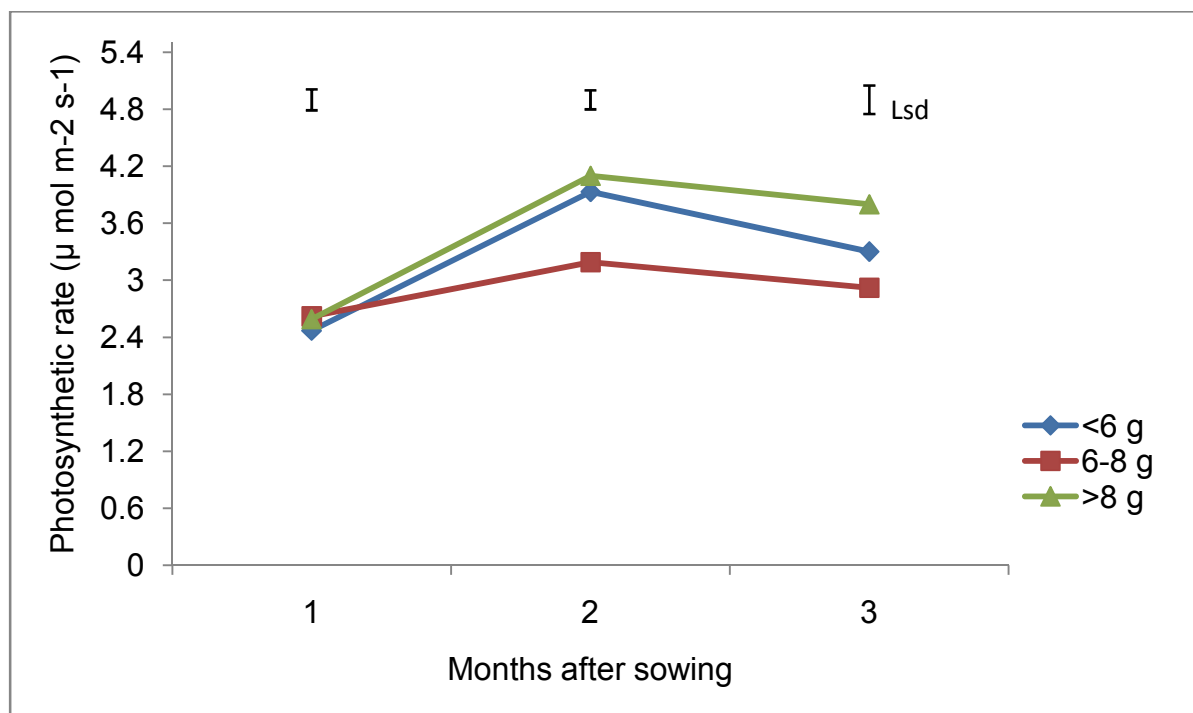


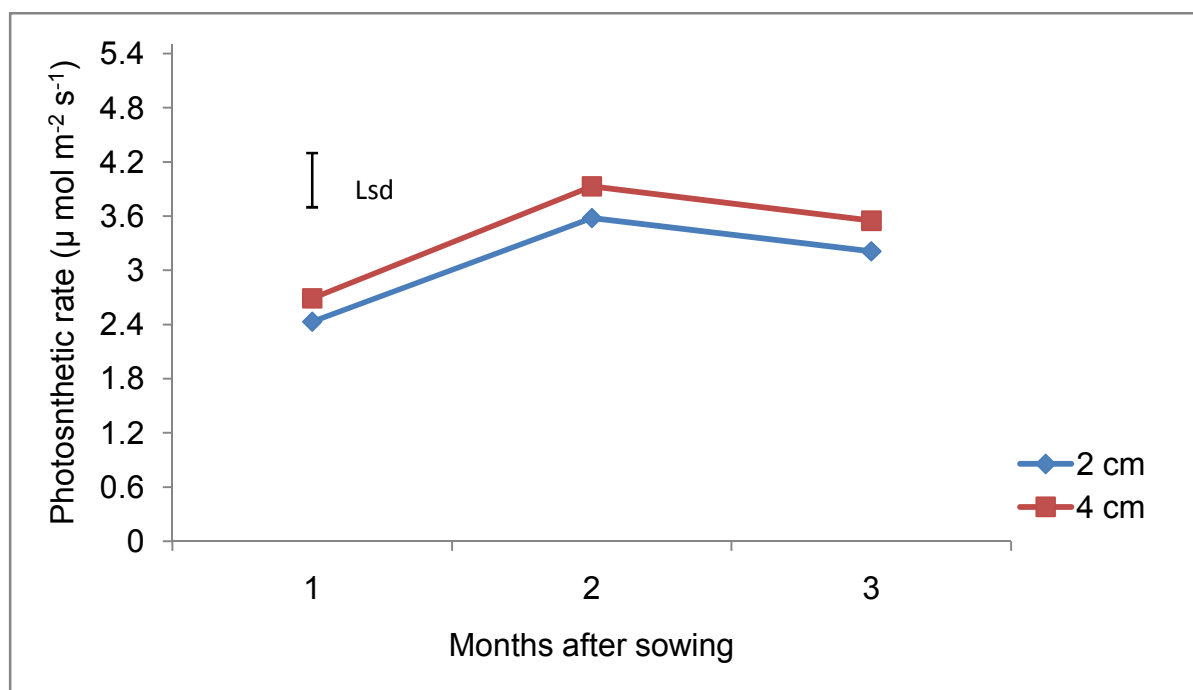
Fig 3b

Fig 1.3 Effects of nut weight (a) and sowing depth (b) on chlorophyll fluorescence of cashew seedlings at various times after sowing in the nursery.



311

312 Fig 4a



313

314 Fig 4b

315 Fig 1.4 Effects of nut weight (a) and sowing depth (b) on rate of photosynthesis of
 316 cashew seedlings at various times after sowing in the nursery.

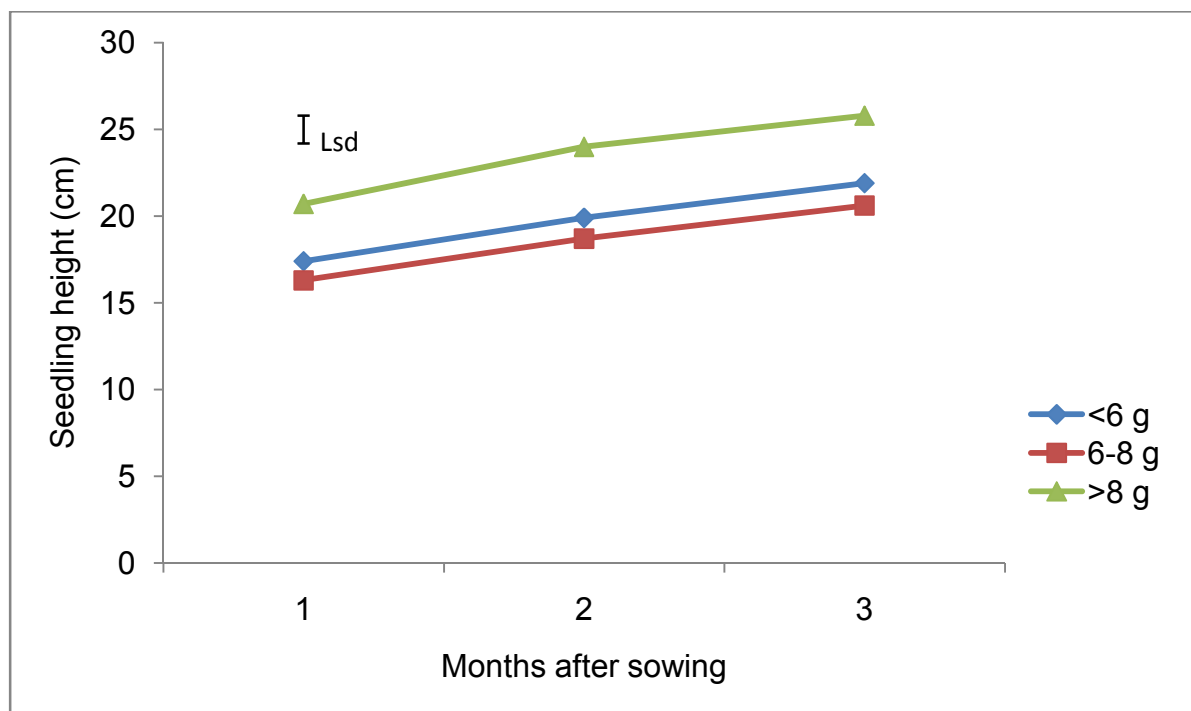


Fig 5a

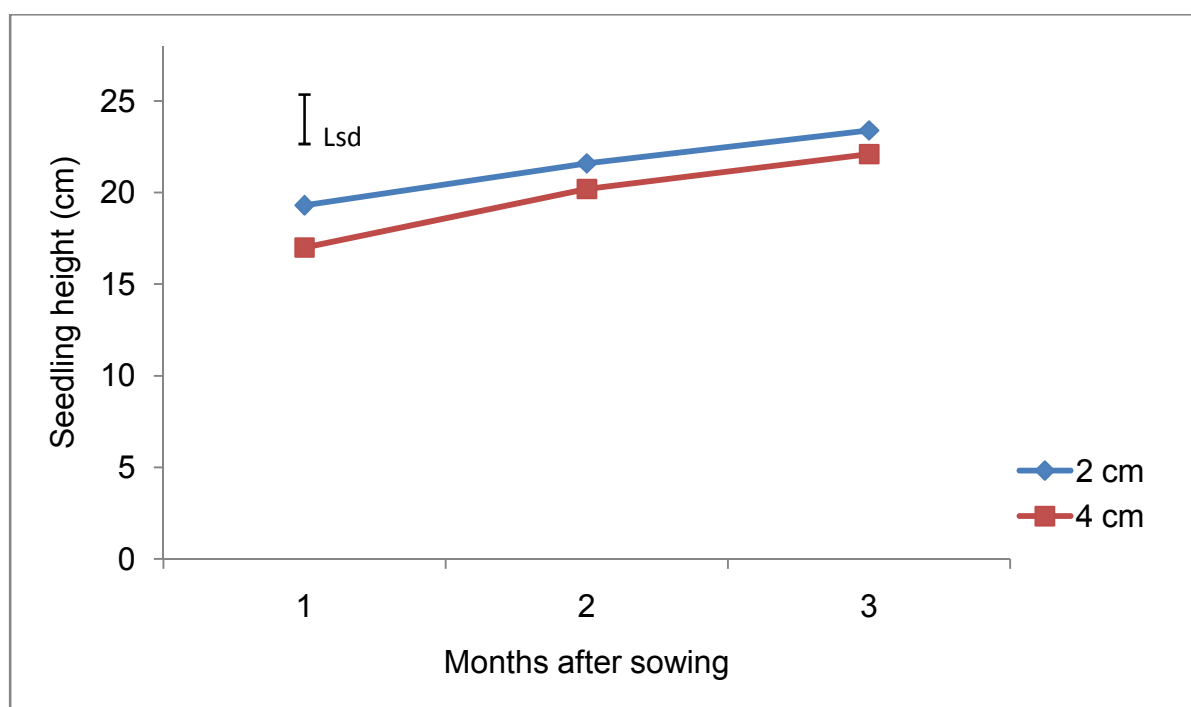
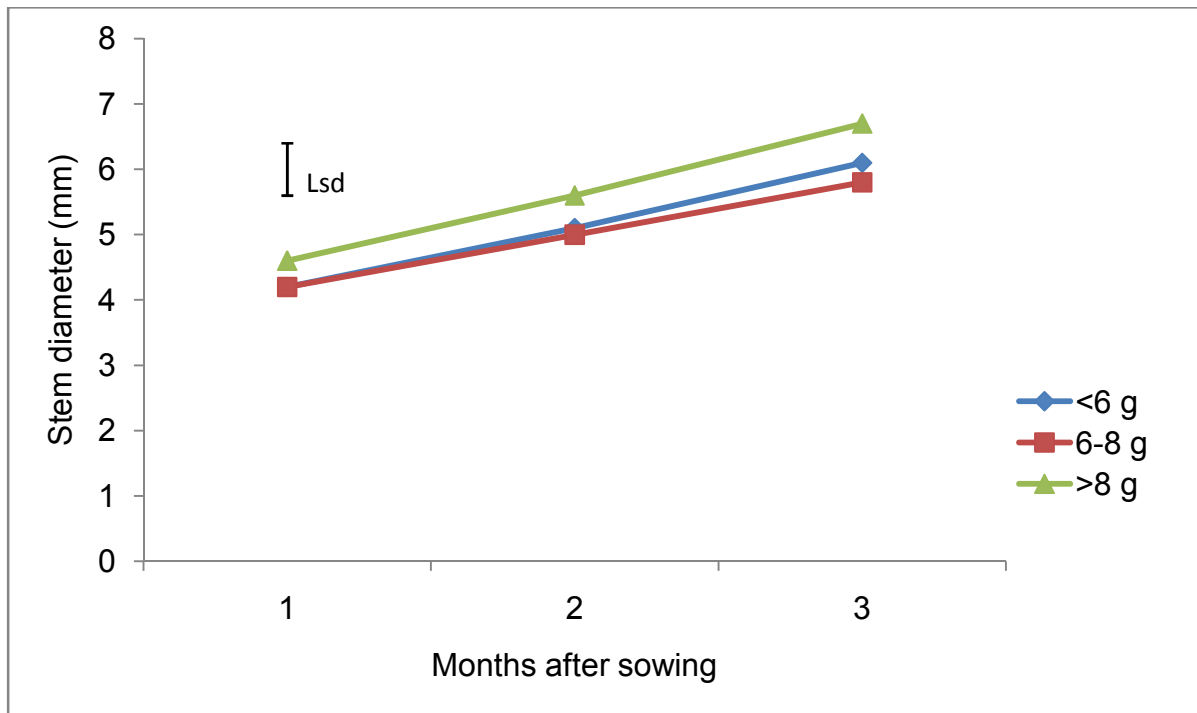


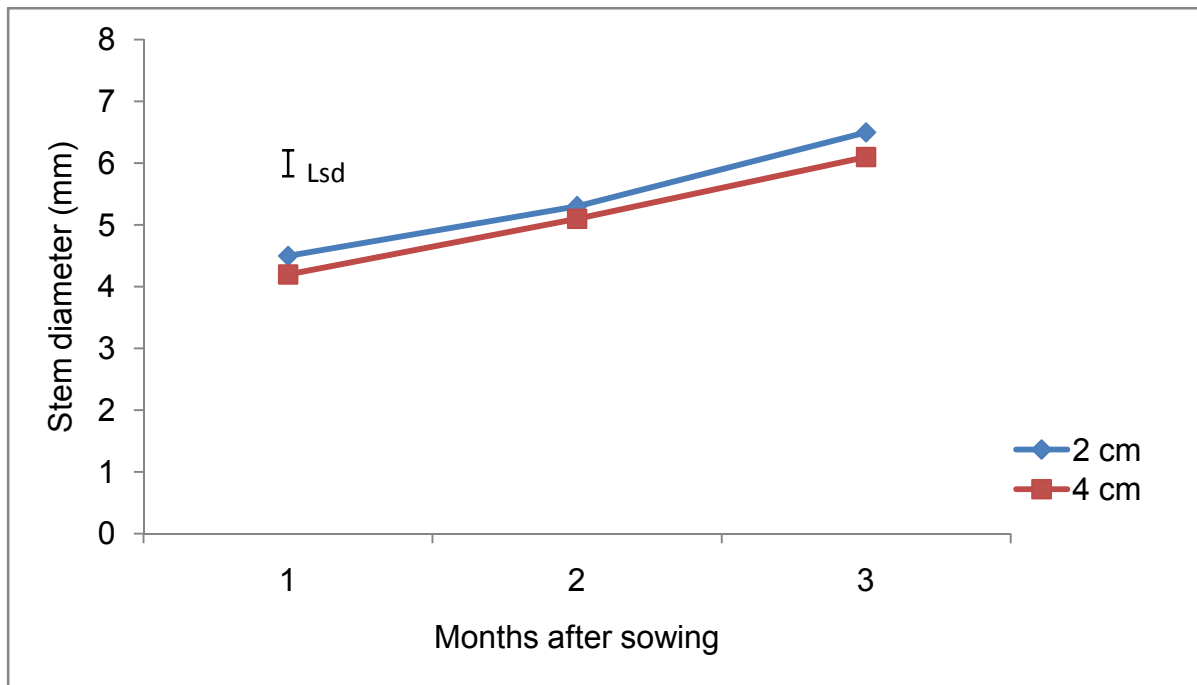
Fig 5b

Fig 1.5 Effects of nut weight (a) and sowing depth (b) on height gain by cashew seedlings at various times after sowing in the nursery.



323

324 Fig 6a



325

326 Fig 6b

327 Fig 1.6 Effects of nut weight (a) and sowing depth (b) on diameter gain by cashew
 328 seedlings at various times after sowing in the nursery.