EFFECT OF EARLY REMOVAL OF APICAL BUD AND PRUNING REGIMES ON PRODUCTIVITY OF PIGEON PEA [*CAJANUS CAJAN (*L) MILLSP]

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ABSTRACT

Two trials were conducted at the Federal University of Agriculture, Abeokuta to evaluate the combined effect of early apical bud removal (ABR) and severity of pruning on the performance of pigeon pea. In the field, 7 treatments arranged in Randomized Complete Block Design comprised of stem pruned at 25, 50, or 75 cm above the soil with or without ABR and a control plot. In the screenhouse, 5 pruning regimes (no pruning, 25, 50, 75 and 100 cm above the soil) with or without ABR were arranged in completely randomized design. Both trials were replicated thrice. The ABR was at 5 and 7 WAP (weeks after planting) and pruning was done at 16 and 12 WAP in Experiments 1 and 2 respectively. ABR and pruning led to 37.5 to 62.4 % reduction in grain yield on the field and significantly ($p<0.05$) increased plant biomass in both trials. Stem girth, dry weight, number of branches, and height at first branching were significantly influenced by pruning severity ($p<0.05$) in the screenhouse. In both trials, fastest re-growth was recorded from plants pruned to 50 cm ($p<0.05$). Least value for percentage survival (85 %) was recorded from plants pruned to 25 cm in the field; no mortality was recorded in the screenhouse. It was concluded that early ABR did not stimulate lateral branches closer to the soil surface; pruning to 50 cm above the soil level is still the most adequate that combines high survival rate, biomass production and appreciable grain yield in pigeon pea management.

Key words: apical bud, pruning severity, lateral branching, pigeon pea survival

INTRODUCTION

Maintenance and improvement of soil fertility remain some of the challenges of sustainable crop production in the humid tropics. Crop husbandry practices that have been identified for this purpose include mulching, green manuring, intercropping, green fallow periods and agroforestry (van Scholl and Nieuwenhuits, 2004). Pigeon pea (*Cajanus cajan* (L) Millsp.) is an important multipurpose shrub legume of the tropics and subtropics. It is a legume which helps to replenish soil fertility. Many factors have contributed to widespread cultivation of pigeon pea. It is the only fast growing shrub introduced for alley cropping, which combines production of green manure with that of food (ICRISAT, 1986). It is also grown for food, feed, firewood, medicine, fencing, roofing, shade, and making of baskets (Shanower *et al*., 1999; Upadhyaya *et al*., 2006). Pigeon pea is a perennial shrub with a deep taproot; they are able to take up nutrient and water from lower subsoil layers. One of the constraints in alley cropping is the shading of the crop grown in the alleys. Pruning of the alley species is thus carried out both to reduce competition for light as well as to produce organic material for soil fertility improvement. In practice, pigeon pea is subjected to pruning when grown as an alley species or as a green manure. The frequency of pruning is mostly dependent amongst other factors, on the height of the crop grown in the alley and its competitiveness for limiting resources, availability of moisture to the alley species which is closely linked to the time of the season and how tolerable is the alley species to severe pruning. Fast re-growth after pruning is considered a positive attribute of an alley species in order to obtain enough biomass to be incorporated in the alley; however in the alley production systems, the shorter the alley species can be cut, the better for the system in order to reduce drudgery associated with repeated pruning. The severity of pruning has been reported to have affected the survivability and the rate of re-growth (Fabunmi *et al*., 2010). It is therefore imperative to improve on the pruning treatment of pigeon pea without increasing the mortality. According to Maata *et al.* (2017) making reference to Acquaah (2009) and McSteen (2009), apical dominance, a natural response in many plants, is particularly manipulated by the horticulturist by processes such as pruning and grafting to determine the shape, size and productivity of many fruiting trees and bushes. Early loss of apical meristem in pigeon pea has led to a bushy shrub like growth habit with a number of spreading branches (Tayo, 1986). The objectives of this study were therefore to evaluate the survivability, biomass production and grain yield of pigeon pea as affected by the combined effect of early loss of apical meristem and pruning severity as it is thought that increased number of branches down the stem, stimulated by early loss of apical meristem prior to pruning treatment, could increase tolerance to more severe pruning and thus reduce the frequency and cost of pruning.

MATERIALS AND METHODS

Two trials were carried out at the University of Agriculture, Abeokuta (7 $^{0}15^{1}$ N, 3^{0} 25^{1} E) from June to December 2009, and January to May 2011. The first trial was carried out on the field using randomized complete block design comprising of seven treatments: pigeon pea pruned back to 25, 50, and 75 cm above the soil level with or without prior apical bud removal and a control (with neither removal of apical bud nor pruning treatment). The second trial carried out in a screenhouse, was a 2x5 factorial experiment arranged in a completely randomized design (CRD) replicated three times. The treatments were five pruning regimes at 25 cm, 50 cm, 75 cm, and 100 cm, above the soil and un-pruned check (control), each with or without removal of apical bud before pruning. Planting in the field was done after manual clearance to rid the field of weed and residue of cassava from previous harvest. Pigeon pea was planted on the 1st of June, 2009. Three seeds were planted per hole and later thinned to one plant per stand at inter and intra row spacing of 150 cm and 25 cm respectively. The screenhouse experiment was carried out to prevent any form of accidental removal of the apical bud that could occur on the field by insect or rodents. Soil from the farm area of the University was collected homogenized by mixing thoroughly and 10 kg of the homogenized soil was put in each pot and water applied. Two seeds were sown per pot and later thinned to one seedling per pot at two weeks after planting; water was applied every other day. Planting date was 7 January 2011. Apical bud was removed at 5 and 7 WAP (weeks after planting), while pruning was done at 14 and 12 WAP in the field and screenhouse trial respectively. Plant biomass collected after pruning was weighed and applied in situ as mulch. Data on plant height was taken by using meter rule to measure the plant from the soil level to the tip of the plant; canopy width of the plant was taken by measuring the width across the plant canopy. Other parameters taken include stem girth, fresh and dry weight of biomass derived from pruning, number of branches per plant and the number of plants that survived four weeks after pruning. Grain yield was not obtained from the screen house trial because pigeon pea is photosensitive and only begins to flower around late October to early November. All data collected were subjected to analysis of variance and significant means were separated using least significant difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Effect of apical bud removal and pruning severity on plant height of pigeon pea

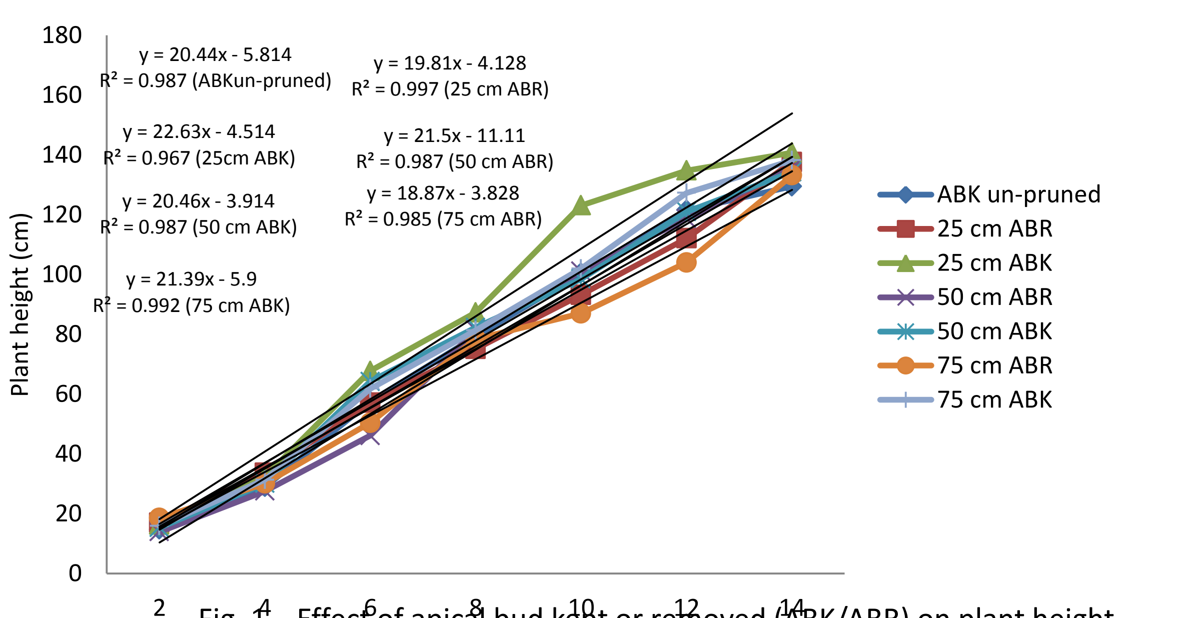

Fig. 1. Effect of apical bud kept or removed (ABK/ABR) on plant height of pigeon pea between 2-14 weeks after planting before pruning at different height (25,50 or 75 cm) in the field.

Plant height of pigeon pea was significantly affected by both apical bud removal and pruning height in this study. In the field trial, plant height was significantly affected by apical bud removal at 6, 8, 12 and 14 WAP. At 8 WAP, all treatments with apical bud intact were significantly taller ($p<0.05$) than those with apical buds detached. Response of plant height of pigeon pea to apical bud removal prior to pruning treatment is presented in Figure 1. The R^2 value was between 0.967 – 0.997 indicating a high positive linear relationship between the plant height and the duration of growth; that is as the duration of growth increases, the plant height increases. The slope coefficient for plant with apical bud intact was 20.44 – 22.63, while that of plants with detached apical bud was 18.87 – 21.50; implying a higher rate of increase in plant height of pigeon pea when the apical bud was retained. (Figure 1).

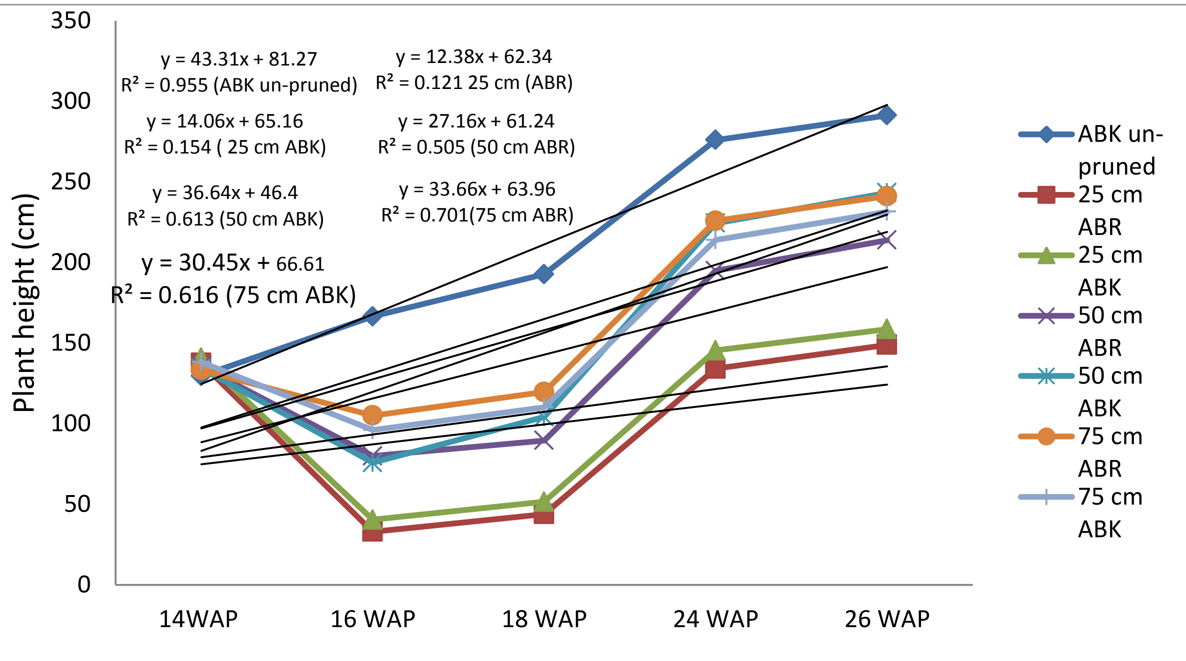

Fig. 2. Effect of height of pruning with or without apical bud removal /kept (ABR/ABK) on plant height of pigeon pea between 14-26 weeks after planting in the field

Plant height of pigeon pea after pruning for field trial is shown in Figure 2. At 16 – 26 WAP, significant response was observed between plant heights of different pruning treatment, plants pruned to 25 cm were the shortest while the plants used as control were consistently taller than other treatments (Figure 2). After applying the pruning treatments, the slope coefficient of the control remained the highest (43.31). Amongst the pruning treatments, the slope coefficient of plants cut back to 50 cm (without prior apical bud removal) was the highest (36.64), while 14.06 for that cut back to 25 cm was the least (Figure 2). The slope coefficients of plants with apical bud removed were 12.38, 27.16 and 33.66 for treatments cut back to 25,50 and 75 cm above soil level respectively. These results imply that on the average, the rate of re-growth of treatments pruned to 50 and 75 cm above the soil over the period of observation were similar; and that plants pruned to 50 cm were superior to those pruned to 75 cm in terms of rate of re-growth if apical bud was kept intact until pruning (Figure 2).

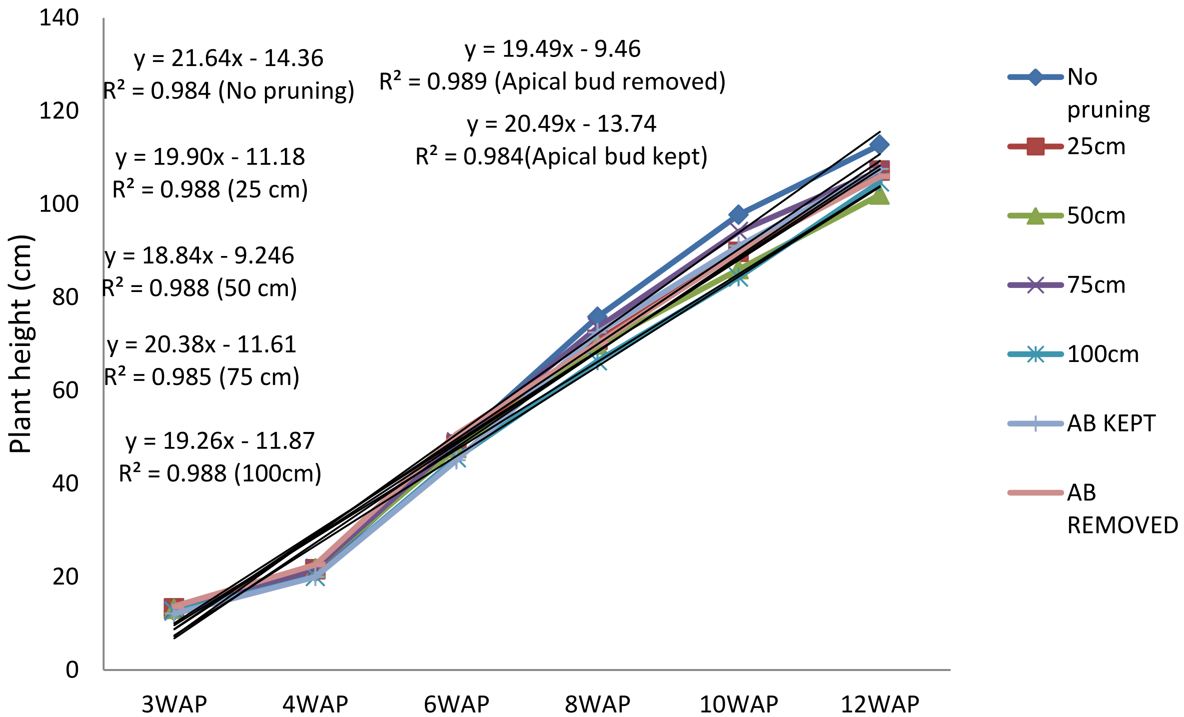

Fig. 3. Effect of apical bud removal/kept (ABR/ABK) on plant height of pigeon pea in the screen house in 2011

Results of the screen house experiment in 2011 showed that plant height of pigeon pea did not respond significantly to removal of apical bud ($p>0.05$), however the R^2 value was between 0.984 – 0.989 indicating a high positive relationship between the plant height and duration of growth (Figure 3). The slope coefficient of plant with retained apical bud was 20.49, while when apical bud was removed it was 19.49. This result is similar to observations made in the field trial (Figures 1 and 2).

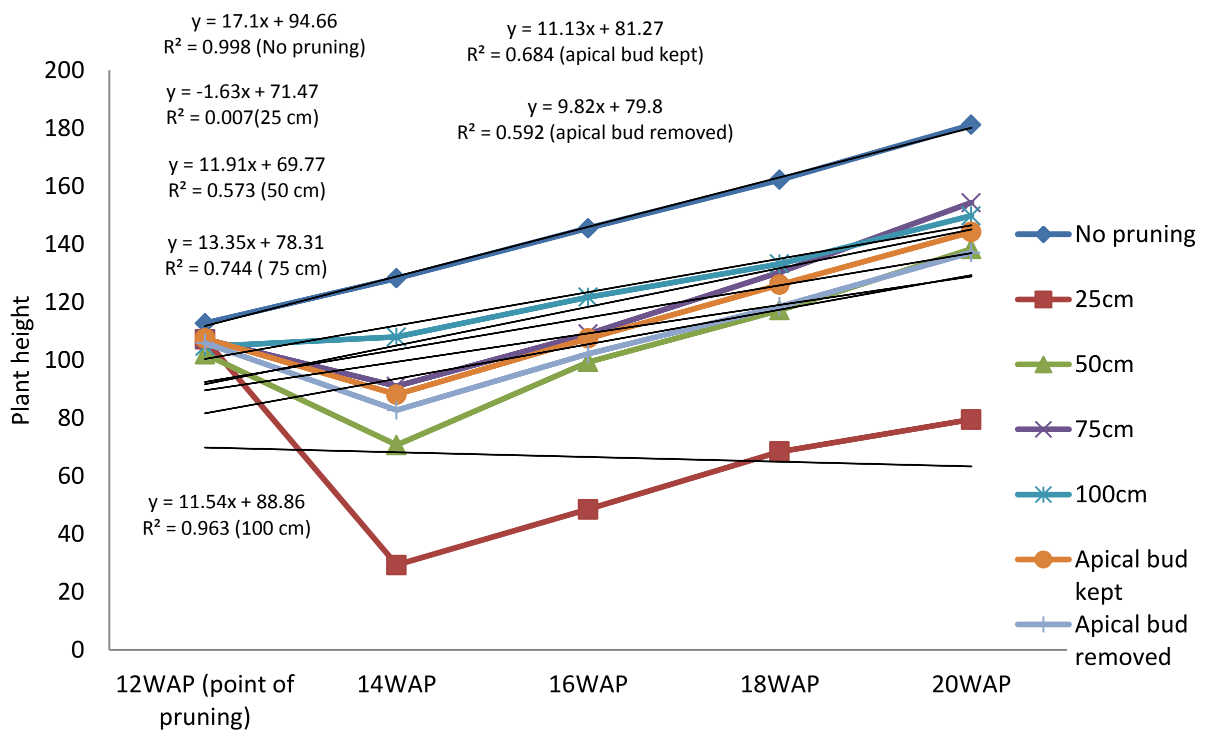

Fig. 4. Effect of apical bud removal and pruning height on plant height of pigeon pea at 12-20 weeks after planting(WAP)

After the pruning treatment in the screen house, plants on the control plot consistently had taller plants from 14 – 20 WAP due to pruning severity, while plants pruned to 25 cm stump were shorter than plants from other treatments. The slope coefficient of plants pruned back to 25 cm was the least (-1.63) implying the least rate of re-growth for this treatment within the 8 weeks of measurement; plants cut back to 25 cm were also yet to attain the height attained prior to pruning 8 weeks after pruning. Slope coefficients for plants cut back to 100, 50 and 75 cm were 11.54, 11.91 and 13.35 respectively; while 9.82, 11.13 and 17.1 were recorded for plants with apical bud removed, retained and control respectively (Figure 4).

In this study the plant height of pigeon pea ranged between 102 – 112 cm at 12 weeks after planting and 133 – 140 cm at 14 weeks after planting in the screen house and on the field respectively. Plant height of 150 cm at 14 weeks after planting had also been reported (Valenzuela and Smith, 2002).The significant increase in plant height observed in treatments with apical bud retained as compared to corresponding treatment with apical bud removed might be due to stimulation of lateral branches in treatments with apical bud detached. This could be attributed to the fact that when apical meristem was removed, lateral buds that were suppressed and dormant became active while the increase in the height of the initial dominant shoot was suspended. Height of the plant in question then became a function of how fast the lateral shoot(s) increase in height as it replaces the main shoot*;* removal of auxin alongside the meristem is responsible for this. Early loss of apical dominance at 3 and 7 weeks after planting was reported to have led to increased vegetative development in dwarf variety of pigeon pea (Tayo, 1982). In recent times, production and transportation of auxin from the shoot tip to the lateral buds to suppress their activity while the apical bud is intact has been contested as the initial reason for apical dominance. According to Mason, *et al*. (2014) the intense demand for sugar by the actively growing shoot tip limits availability to the lateral buds and thus suppress their growth, this they claimed to be the initial regulator of apical dominance.

Effect of apical bud removal and pruning severity on canopy width of pigeon pea

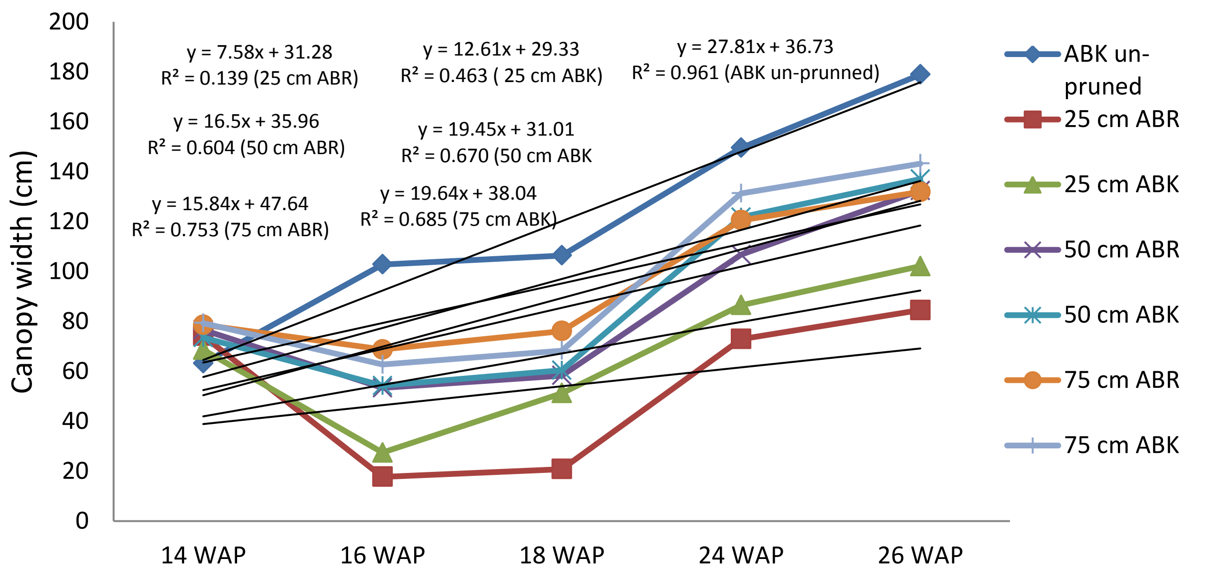

Fig. 5. Effect of apical bud removal (ABR) or apical bud kept (ABK) and height of pruning(25,50, 75 cm) on canopy with of pigeon pea at different weeks after planting (WAP)

Figure 5 presents canopy width of pigeon pea as affected by apical bud removal on the field. The slope coefficient of the control was the highest (27.81). Slope coefficients of treatments pruned to 50 cm with or without prior apical bud removal were 16.5 and 19.45 respectively and were the highest amongst the treatments. Similarly slope coefficients of plants with apical bud removed or retained prior to pruning were 15.84 and 19.64 respectively. The treatment with the least slope coefficient for canopy width was 25 cm pruning.

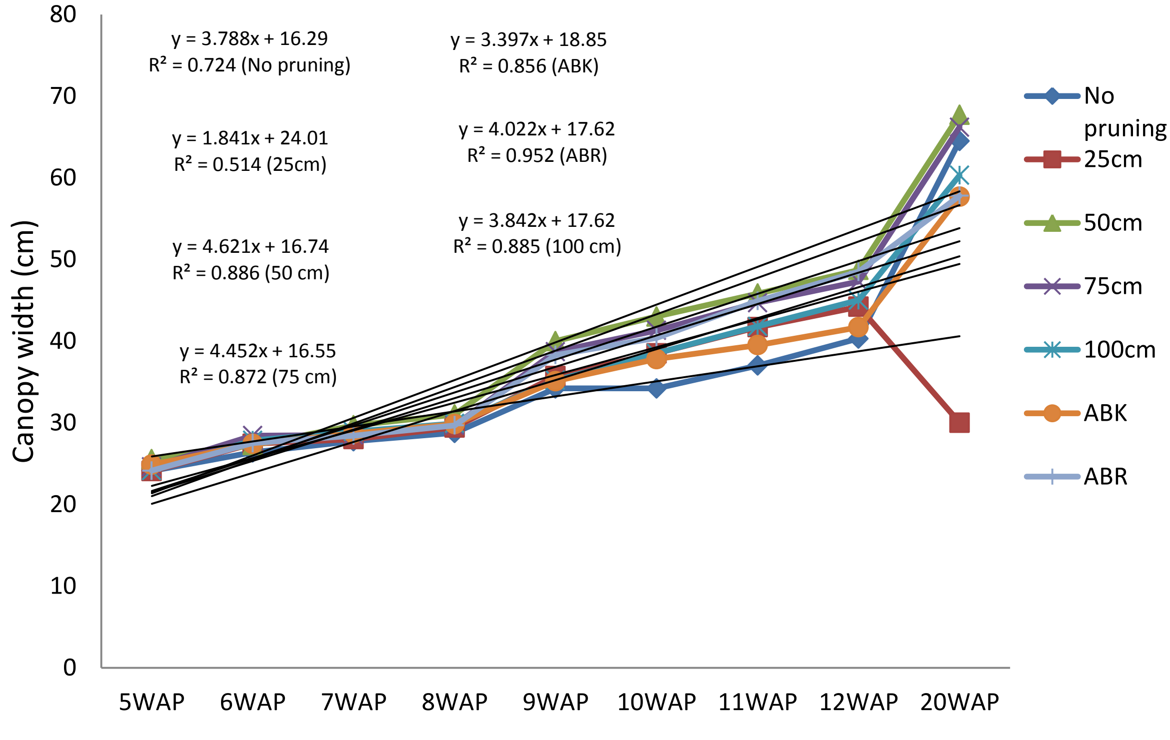

Fig 6. Effect of apical bud removal /kept (ABR/ABK) and pruning at 25, 50, 75 and 100cm on canopy width of pigeon pea

Canopy width of pigeon pea in the screen house is presented in Figure 6. Treatment pruned back to 50 cm also produced plants with highest slope coefficient of 4.621 for canopy width compared with 1.84 value recorded for plants pruned to 25 cm; 4.45 and 3.84 for those pruned to 75 and 100 cm respectively.

Significant increase in canopy width of plants with detached apical bud relative to plants with retained apical buds in the field trial at the point of pruning, and consistent higher values observed in canopy width from the 9th to 12th week in the screen house could be due to the stimulation of lateral growth after the removal of apical bud; after the removal of apical buds, more nutrients including photo assimilates were made available for the growth and expansion of the lateral buds (Mason, *et al*., 2014), leading to the extension of the lateral branches .

Effect of apical bud removal and pruning on grain yield

The grain yield of pigeon pea in this trial ranged between 125-320 kg/ha. Grain yield of pigeon pea from the field trial in 2009 showed a significant response between different treatments and the control. Grain yield from the control plot was more than 200% of the yield obtained from plants pruned to 25 and 50 cm and more than 150% of the yield obtained from plants pruned to 75 cm stump (Table 1).

The response of grain yield to apical bud removal and pruning severity in this study revealed that pruning pigeon pea to 25 cm without prior removal of apical bud gave similar grain yield as compared to those pruned to 75 cm. Furthermore, both apical bud removal and pruning severity led to 61.6, 54.8 – 62.4, and 37.5 – 48.0 percent reduction in grain yield for pruning regime of 25, 50, and 75 cm respectively as compared to the un-pruned. This could be attributed to the fact that there was reduction in total available biomass in pruned treatments at the seed initiation and seed filling stage as compared to control plots; thus more tendency for assimilate production and partitioning to the grains in control plots relative to other treatments. Agyare *et al*. (2002) similarly reported that the highest seed yield of pigeon pea was obtained from the no-pruning treatment as compared to yield from those pruned to 30, 60 and 90 cm. The implication of this is that the advantages derived from more severe pruning like higher biomass production for enhanced soil fertility as well as reduced frequency and cost of pruning must be weighed alongside with the reduction in grain yield before the farmer will take his final decision. The grain yield obtained in this study is however low compared with the range of 723 – 2,710 kg/ha obtained from improved varieties (Ezeaku, *et al*., 2016). The reason is because the local pigeon pea variety was used for this study.

Effect of apical bud removal and pruning on survival percentage

In the field trial, survival percentage varied significantly between different treatments; while the control plots and plants pruned to 75 cm had 100% survival, there was 1 – 2% mortality by pruning to 50 cm and 13 – 15% mortality when pruned to 25 cm (Table 1). No mortality was however recorded in the screen house experiment across the treatments.

Although the survival percentage varied significantly between different treatments in this trial with percentage mortality of 13 – 15% when pruned to 25 cm in 2009, the 100% survival recorded across all treatments in the screen house could be due to higher risk of further pest attack on the field aggravating the impact of pruning. This suggests that if pruning is done carefully, pigeon pea can be pruned to as low as 25 cm without leading to high mortality. Caution that has to be exercised here is to ensure that the bark (containing the phloem) of the stem is not allowed to tear off the wood beyond the specified pruning height.

Effect of apical bud removal and pruning severity on pruning's biomass and stem girth of pigeon pea.

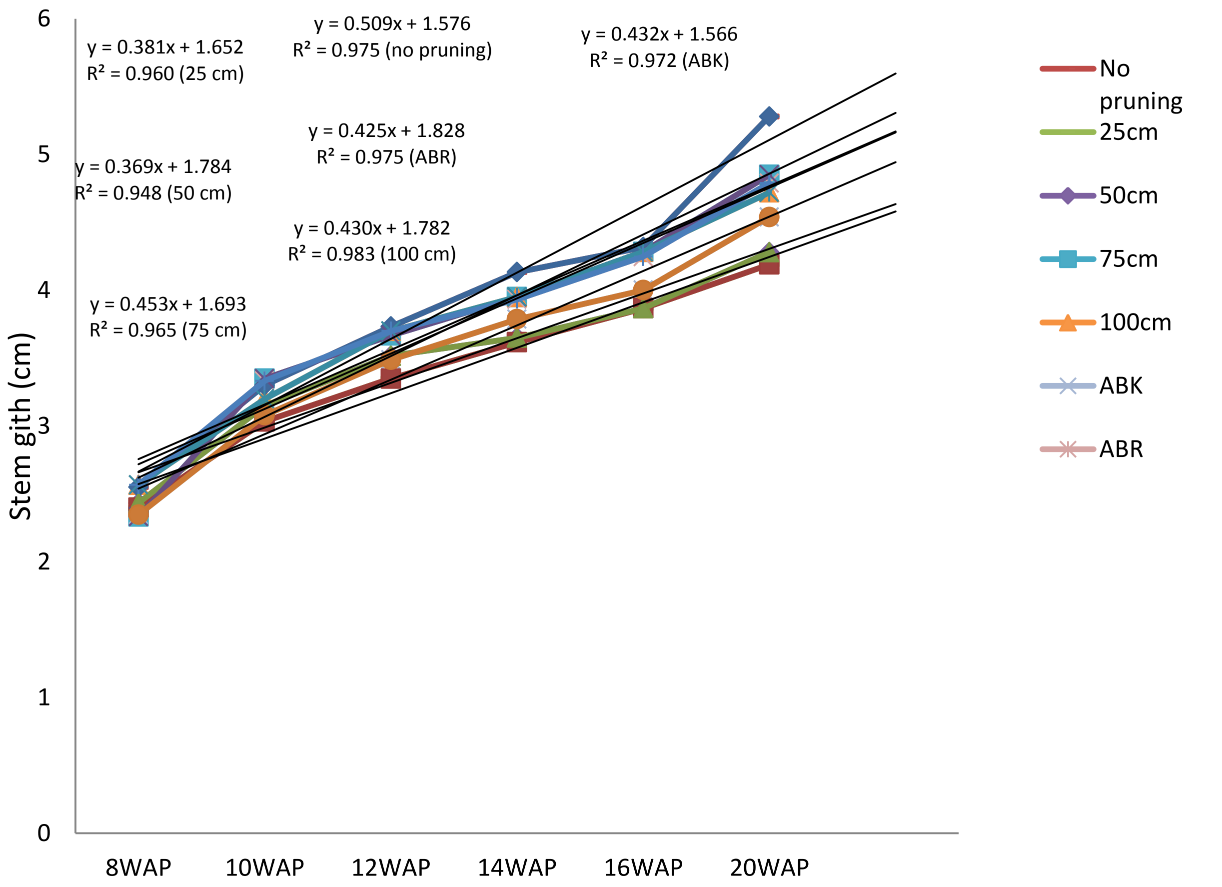

Fig. 7 Stem girth of pigeon pea between 6-20 weeks after planting as influenced by apical bud removal /kept (ABR/ABK)and stem pruning at 25, 50, 75 or100 cm above the soil in the screen house.

Stem girth taken in the field at 10 weeks after pruning differ significantly between treatments in 2009, a definite trend was however not established (Table 1). In the screen house stem girth were consistently similar ($p>0.05$) for the first 16 weeks of experimentation, however stems of plants on the control plot were significantly bigger than those pruned to 25 and 50 cm at 20 WAP; Slope coefficients recorded for stem girth were 0.509, 0.432 and 0.425 for plants in the control plots, those with retained apical bud and those with detached apical bud respectively; while the least slope coefficient for stem girth (0.369) was recorded for plants pruned to 50 cm (Figure 7).

Table 1. Effect of apical bud removal and pruning severity on stem girth, pruning's biomass, grain yield and survival percentage of pigeon pea in 2009

Treatment	Stem girth(cm)	Pruning fresh weight (t/ha)	Grain yield (Kg/ha)	Stand count before pruning	Stand count after pruning	Survival percentage
ABR un-pruned	10.6	-	319.7	36.3	36.3	100
25 cm ABD	6.7	4.467	127.9	34.0	29.0	85.1
25 cm ABR	7.0	3.300	127.9	35.0	30.3	86.7
50 cm ABD	8.3	1.630	125.0	36.0	35.3	97.9
50 cm ABR	9.1	2.717	150.3	37.7	37.3	99.1
75 cm ABD	10.0	2.660	173.0	36.7	36.7	100
75 cm ABR	8.5	2.660	207.9	38.3	38.3	100
LSD	2.00	1.648	79.71	NS	7.9	8.96

ABD = apical bud detached ABR = Apical bud retained WAP = weeks after planting

Plant biomass obtained from pruning for the field trial was significantly affected by height of pruning. Pruning to 25 cm gave the highest fresh biomass (Table 1). In the screen house both height of pruning and apical bud removal significantly affected pruning's biomass (Table 2). Apical bud removal led to production of significantly higher ($p<0.05$) biomass in the screen house. There was 56 % increase in the biomass production due to apical bud removal compared to retention of apical bud (Table 2). Biomass derived from pruning to 25 cm stump was the highest and similar ($p>0.05$) to pruning's from 50 cm and were significantly higher than biomass obtained from 75 cm and 100 cm; generally, the more the severity of pruning, the more the biomass produced.

Table 2. Effect of apical bud removal and pruning severity on pruning's fresh and dry weight, number of branches, and height of first branch of pigeon pea, in the screen house in 2011.

Pruning treatments	Pruning's fresh weight at 12WAP(g/plant)	Pruning's dry weight at 12WAP(g/plant)	Number of branches at 18WAP	Height of bottom-most branch
No pruning	-	-	4.83	19.7
25cm	41.4	11.69	3.08	16.0
50cm	30.2	8.85	4.50	22.7
75cm	17.5	5.48	6.50	28.3
100cm	5.1	1.64	4.17	40.0
LSD	15.21	4.495	1.796	13.48
Apical bud				
Kept	18.3	5.44	4.50	22.2
Removed	28.7	8.39	4.73	28.5
LSD	9.62	2.843	NS	NS
Apical bud x pruning				
LSD	NS	NS	NS	NS

WAP = weeks after planting NS= not significant

In this trial the slope coefficient of stem girth for treatment pruned to 50 cm above the soil was lower than that recorded for other pruning treatments, even though plants pruned back to 50 cm showed superiority in terms of rate of re-growth of both the plant height and canopy width. This could be due to competition for assimilate between these plant parts since the three processes (increase in plant height, canopy width and stem girth) occurred simultaneously.

The significant increase in biomass production due to apical bud removal and pruning severity can be attributed to both lateral branch stimulation as well as increased vegetative materials with increased severity of pruning. More lateral branches produced made more biomass available at the point of pruning; Tayo (1982) similarly reported higher dry matter accumulation in pigeon pea due to early loss of apical dominance and the removal of apical bud stimulate lateral branches which allows dormant bud to develop at nodes down the stems (Tayo, 1986). This was not as consistent in the field trial; there is the tendency for apical bud removal on the field by pest like bush rabbit which could forage on pigeon pea.

The biomass obtained from pruning (fresh weight 1.63 – 4.47 t/ha) across treatments in this study could be considered to be within the range of 5.1 t/ha in 5 months reported as common in Nigeria (Valenzuela, 2011). This is because the fresh weight was taken at 14 WAP that is 6 weeks earlier than the time reported; also rapid growth of pigeon pea often starts after 8 weeks of planting.

Effect of apical bud removal and pruning severity on number of branches and height at first branching of pigeon pea

Number of branches and height of first branch were taken in the screen house trial; both parameter were not significantly affected by apical bud removal ($p>0.05$) (Table 2); first branch was higher up on the stem when apical bud was detached relative to plants with apical bud retained. On the other hand both number of branches and height of first branch were significantly affected by height of pruning ($p<0.05$). Pruning at 75 cm gave the highest significant number of branches amongst all the pruned treatments, the value of which was similar ($p>0.05$) to the control treatment. Pruning at 100 cm produced plants with the first branch farthest from the soil; while apart from the plants pruned to 25 cm, the control plot produced plants with first branch closest to the soil level (Table 2).

From the above results the first branch of plants with detached apical bud were higher up the stem compared with those with retained apical bud. This suggests that early detachment of apical bud before pruning of pigeon pea will not activate dormant buds closer to the soil to have increased the possibility of pruning closer to the soil level as earlier reasoned before the commencement of this trial.

ICRISAT (1992) reported that the branching pattern in pigeon pea depends on genotype and spacing between rows and plants; and that pigeon pea may form a bush at a wide spacing while remaining compact and upright at narrow spacing. According to Dun *et al*. (2006) in intact plants, and to a lesser extent in decapitated plants, the intrinsic or extrinsic thresholds or limitations for responses to branching signals are determined by the location of buds, plant developmental stage, and environmental factors, such as light, carbon acquisition, and nutrients. Thus in this trial lack of activation of dormant buds closer to the soil by early decapitation prior to pruning could be because at this developmental stage, branching is premature and probably because pigeon pea naturally grow slowly; even when the apical meristem is kept intact, rapid growth only begins at about 8 weeks after planting, early branching in this plant is thus, not just controlled by the suppression of lateral buds by the presence of apical bud or apical dominance but by the developmental stage as well.

Effect of apical bud removal and pruning severity on rate of re-growth pigeon pea

Table 3. Rate of re-growth of pigeon pea on the field as affected by apical bud removal and pruning severity in 2009

	Height at pruning (cm)	Increment in plant height of pruned plants (cm) at different weeks after Pruning			
Treatment	14 WAP	2	4	10	12
25 cm ABD	137.6	7.9	18.9	109.1	123.9
25 cm ABR	140.8	14.6	26.5	120.4	133.6
50 cm ABD	135.5	29.9	39.5	144.9	163.8
50 cm ABR	134.3	25.7	54.1	174.3	193.2
75 cm ABD	133.2	30.0	44.6	150.8	166.1
75 cm ABR	138.2	24.0	35.2	138.9	156.3
LSD	NS	15.45	15.45	19.93	20.03

ABD = apical bud detached ABR = Apical bud retained WAP = weeks after planting

Table 4. Effect of apical bud removal and pruning height on rate of re-growth of pigeon pea after pruning treatment in the screen house

	Height at pruning	Increment in plant height of pruned plants (cm) at different weeks after pruning			
Treatments	12WAP	2	4	6	8
Pruning					
No pruning	112.7	-	-	-	-
25cm	107.2	4.3	23.5	33.4	54.5
50cm	102.0	20.7	49.3	67.2	88.3
75cm	107.2	16.0	34.0	55.3	79.3
100cm	104.7	8.0	21.7	33.2	49.8
LSD	NS	4.60	11.92	15.47	20.74

WAP = weeks after planting

The rate of re-growth was slower in treatment pruned to 25 cm relative to those pruned to 50, 75, and 100 cm after the initial pruning. Pruning to 50 cm however showed higher rate of re-growth after pruning in both the screen house and the field (Table 3 and Table 4).

The relatively slower rate of re-growth in treatment pruned to 25 cm as compared to those pruned to 50, 75, and 100 cm after the initial pruning could be attributed mainly to the few photosynthetic apparatus retained after pruning of the former as compared to those pruned to 75 and 100 cm. Pruning to 50 cm however showed higher rate of re-growth after pruning in both the screen house and the field. Agyare *et al.* (2002) observed after considering the annual biomass production and grain yield at pruning to 60 cm is the most promising for crop-livestock production. This result affirms earlier report by Fabunmi (2009) and Fabunmi *et al*. (2010) that pruning of pigeon pea to 50 cm was the best in pigeon pea management when used as an alley crop in pigeon pea/pepper alley cropping.

CONCLUSION

It is concluded from this present study that early apical bud removal had no effect on the number of branches lower down the stem, suggesting that early branching might be more intrinsically controlled in pigeon pea, however at the more rapid growth stage, the greater the severity of pruning, the closer the height of the first branch to the soil. Removal of apical bud and pruning of pigeon pea to 25 – 75 cm above soil level led to up to 38 – 62 % reduction in grain yield. Pruning pigeon pea to 50 cm had fastest rate of re-growth after pruning. It can therefore be concluded that for effective management of pigeon pea in alley cropping, pruning to 50 cm above the soil level was most adequate for the production of high biomass, fast rate of re-growth, high survival rate and appreciable grain yield.

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