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Effect of flower production and time of flowering on pod yield of peanut (Arachis hypogaea L) genotypes

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Abstract : *Field experiments was conducted to determine the role of flower production and flowering pattern on mature pod yield of three groundnut genotypes, and assess relationships among their yield components. The genotypes were harvested over seven weeks. A split-plot design with four replications was used. Five plants were harvested from a plot. Data taken were; 30 days flower count, weekly flower count, matured pods, number of pegs, days to first and 50% flowering. There was significant difference ($P < 0.05$) in the flower production pattern among the genotypes from first to fourth week. Number of flowers was positively correlated ($r = 0.41$, $r = 0.68$, and $r = 0.33$) with mature pods at second, third and fourth week respectively in 'Kpedevi' at 112 DAS. Moreover, number of flowers correlated positively at second ($r = 0.16$) and third ($r = 0.21$) week in 'Chinese' at 98 DAS. 'F-Mix' at 105 DAS showed a negative correlation with mature pod in all the weekly flower count. The maximum number of flowers produced was an indicator of higher number of mature pods in both the 'Chinese' and 'Kpedevi' variety. However, this was contrary with 'F-Mix' variety since flower count correlated negatively at all weeks with matured pods at 105 DAS.*

Keywords: *Days after sowing (DAS), flowering, Genotypes, mature pods.*

I. INTRODUCTION

Groundnut (Arachis hypogaea L) is among the major leguminous crops grown in Ghana and it is the third largest oilseed crop after soybean and seed cotton globally (Marfo et al., 1999). About two-thirds of world production is used for oil extraction and it is an essential source of vegetable protein and oil in sub-Saharan Africa (FAO 2002–04; Marfo et al., 1999). Groundnut seed contains 44 % to 56% oil and 22% to 30% protein on dry seed basis and is a rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (Savage and Keenan, 1994). Groundnut root nodules can fix high amount of atmospheric nitrogen and enhances the sustainability of the farming in Ghana, and the haulm is used as fodder (Marfo et al., 1999). The young pods may be consumed as a vegetable whiles young leaves and tips are utilized as cooked green vegetable (Martin and Ruberte, 1975).

In groundnuts, the basic reproductive units constitute the flowers. Flowering and flowers play an important role in all seed crops, yield is dependent largely upon the basic reproductive units available.

The total number of flowers produced depends upon the genotype as well as between the sequential or alternate type (Usha et al., 1988, Cahaner and Ashri, 1974). Ramanatha Rao. (1988) reported that Groundnut plants start flowering about 30-40 DAS and maximum flower production occurs 6-10 weeks after planting.

Groundnut produces more flowers than the plant can sustain and develop into pods and less than 15 % to 20 % of flowers produced mature pods (Lim and Hamdan, 1984; Ramanatha Rao and Murty, 1994). Craufurd et al. (2000) suggested that flowering commenced 25 days after sowing and the daily flower production increased progressively with alternations of high and low production. The main flowering period spanned about 40 days after which sporadic flowering were observed. The flowering pattern was similar for all the varieties studied and consisted of two peak periods, one occurring during the first 3 weeks of flowering and the second in the later period of flowering.

Though groundnut is indeterminate, flower numbers continue to increase until the plant reaches peak bloom at about 60 to 70 days after emergence, and then flower development will begin to decline. In bunch genotypes, flowering commenced from 26 to 34 days after sowing (Craufurd et al., 2000).

Ishag (2000) also reported differences in flowering patterns between cultivars. He added that cultivars with a prostrate (Virginia types) growth habit produced more flowers. The total number of flowers produced by peanut plants was highly valuable, ranging from a low of only 18 flowers to a maximum of 142 flowers. He suggested that due to the wide variation in flower numbers, the varieties were not significantly different for the number of flowers produced; an overall mean of 57 flowers per plant was obtained.

The Spanish genotypes of groundnut produced fewer flowers than Virginia genotypes, and this was associated with fewer reproductive nodes and a shorter flower production period. Also, Virginia genotypes are

generally later flowering and initial rates of flower production are lower than in Spanish genotypes. Greater fruit number in the Spanish genotypes was associated with earlier flowering (Craufurd et al., 2000).

Generally, a large number of early formed flowers develop into fruits and flowers that appear 70 days after flowering do not form pods and fail to increase the yield due to low yield of mature pods (Knauft and Gorbet, 1989; Putnam et al., 1991; FAO, 1990). According to Bell et al. (1991) and Awal and Ikeda, (2003) the production pattern of the groundnut flowers favor pod setting and pods take about 8 weeks to mature from the time of flowering and therefore, only the first 3 weeks of flowering may be considered to be useful but this varies among varieties.

Fruiting efficiency depends on the pattern of flowering (number of flowers at different period of flowering), which is more important than total number of flowers per plant (Lim and Hamdan, 1984 and Lee et al., 1972). Plants whose flowering was stimulated set the largest percentage of pegs and high growth rate of intact pegs but plants with the least number of flowers formed the lowest percentage of pegs, and the peg growth rate declined by 50% (Lim and Hamdan, 1984 and Lee et al., 1972).

Corlett et al. (1992) and Önemli, (2005) also indicated that the percentage of flowers turned to pods, but not the number of flowers, is important for determining the yield of groundnut. The flower to peg ratio and peg to pod ratio were good indicators of pod yield and if the relationship between the beginning of the first flowering and maturity is known, the time of harvest can be estimated for healthy crops.

Bailey and Bear (1973) demonstrated that the early onset of flowering and early accumulation of a given number of flowers (10 to 30) are important components of early maturity in groundnut and a high proportion of the first 25 flowers developed into mature pods. Similarly, the conversion of flowers to mature pods was the most important factors contributing to high pod yield (Songsri et al. 2009).

Pod number and eventual crop yield is determined by the number of floral buds that form flowers, the number of flowers that are fertilized and produce pegs, and the number of pegs that successfully penetrate the soil surface and produce pods (Prasad et al., 1999b).

Despite the increase in groundnut yield in the past decade in Ghana, this has been due to increase in land cultivation and not necessary due to increase in the crop agronomic traits (Tsigbey et al., 2003; FAO, 2006). In Groundnut, flowers represent the reproductive unit. If the time of flowering and the number of flowers produced per plant is maximized and synchronized, there will be improved yield. In addition, there is little information on maximizing peanut flowers to increase pod yield especially on this genotypes most grown by farmers in Ghana. Thus, triggering the need for this study.

The objectives of this study were:

1 To determine the role of flower production and flowering pattern on optimum mature pod yield of groundnut.
2 To assess relationships among components of yield at different stages of harvest.
3 To estimate the number of flowers, time of flowering and pattern of flowering of peanut genotypes commonly grown in Ghana.

II. Materials And Methods

2.1 Experimental site

Two field experiments was conducted at the University of Ghana farm, Legon (5 ° 58’ N, 0 ° 8’ W; 153 m above sea level) during the 2010/2011 cropping season. The experimental site is within the coastal Savannah zone, with annual mean rainfall of 750 mm and average temperature of 26 ° C. The soil belongs to the Adenta series, ferric Acrisol (FAO UNESCO, 1990).

2.2 Genotypes and Experimental design

Three local groundnut varieties: ‘Chinese’ (Spanish), ‘Kpedevi’ (Virginia) and ‘F-Mix’ (Virginia) were evaluated. The experiment was laid out in a split-plot design with four replications. The cultivars were the main plots whilst the harvesting dates were the subplots.

The plant spacing was 45cm x15cm. Harvesting was done from 10 weeks after sowing (70 DAS) and subsequently every week until 16 weeks after sowing (112 DAS). At each harvest date, five plants were harvested from a plot.

2.3 Data collected

The following data were collected for both experiments: Days to first flowering, Days to 50% flowering, Number of mature pods (10^{th} to 16^{th} week), Number of pegs (10^{th} to 16^{th} week), Biomass (10^{th} to 16^{th} week), Weekly flower count, and 30 days flower count.

III. RESULT

4.1: Flowering date and flower production pattern

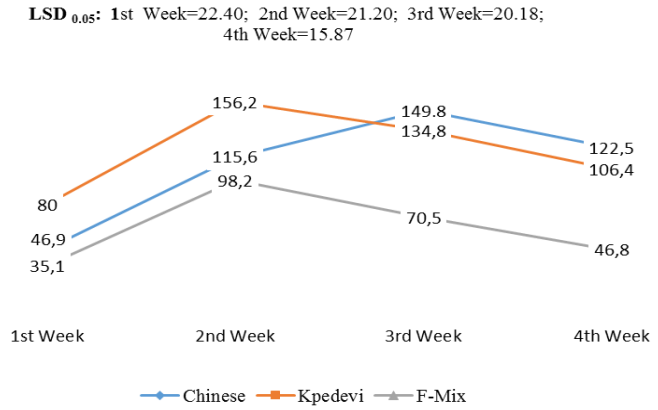

Figure 1: weekly flower production trend.

There was significant difference ($P < 0.05$) in the flower production pattern among the three groundnut genotypes from first to fourth week of flower count. 'Chinese' and 'Kpedevi' genotypes produced a high mean of 149 and 156 flowers per week respectively (Fig1).

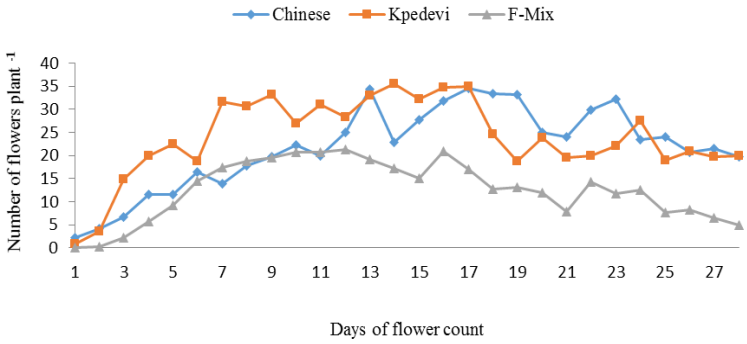

Figure 2: Daily flower production pattern

Also, 'F-Mix' and 'Kpedevi' genotypes were significantly different ($P < 0.05$) in number of flowers produced but 'Chinese' and 'F-Mix' did not vary significantly at first week flower count. 'Kpedevi' at second week was significantly different ($P < 0.05$) from 'Chinese' and 'F-Mix' but 'Chinese' was not significantly different from 'F-Mix' (Figure 1). At third week flower count, 'Chinese' varied significantly ($P < 0.05$) from 'F-Mix' but not with 'Kpedevi'. All the three groundnut genotypes varied significantly ($P < 0.05$) in their flower count at the fourth week (Figure 1).

In the correlation analysis, the 'Chinese' genotype at maximum pod maturity (98 DAS) was positively correlated ($r = 0.16$ and $r = 0.21$) with second and third week flower count respectively (Table 1). Similarly, 'Kpedevi' genotype at maximum pod maturity (112 DAS) showed a positive correlation at second ($r = 0.41$), third ($r = 0.68$) and fourth ($r = 0.33$) week flower count (Table 2). However, at maximum pod maturity (105 DAS), the 'F–Mix' genotype was negatively correlative with all the four weekly flower count (Table 3).

Table 1. Correlation Matrix of weekly Flower and Mature pods at different harvest dates of 'Chinese' genotype.

105 DAS									
112 DAS	0.685								
77 DAS	-0.402	-0.9409							
84 DAS	0.124	0.3117	-0.39						
91 DAS	0.669	0.7863	-0.643	-0.334					
98 DAS	0.084	-0.2331	0.275	0.746	-0.662				
4th WFC	-0.862	-0.6575	0.460	-0.604	-0.324	-0.490			
1st WFC	0.696	0.1604	0.152	-0.586	0.608	-0.288	-0.276		
2nd WFC	0.380	0.8342	-0.902	0.748	0.322	**0.159**^{ns}	-0.640	-0.354	
3rd WFC	-0.126	0.496	-0.715	0.785	-0.071	**0.205**^{ns}	-0.256	-0.770	0.866
	105DAS	112DAS	77DAS	84DAS	91DAS	98DAS	4th WFC	1st WFC	2nd WFC

* = significant at P ≤ 0.05 level. DAS = Days After Sowing; WFC = Week Flower Count.

Table 2. Correlation Matrix of weekly Flower and Mature pods at different harvest dates of 'Kpedevi' genotype.

105 DAS									
112 DAS	0.379								
77 DAS	-0.774	-0.329							
84 DAS	0.548	0.792	-0.794						
91 DAS	0.591	-0.516	-0.366	-0.233					
98 DAS	-0.778	-0.062	0.229	0.046	-0.716				
4th WFC	0.686	**0.325***	-0.991	0.817	0.281	-0.100			
1st WFC	-0.951	-0.381	0.931	-0.703	-0.516	0.558	-0.876		
2nd WFC	-0.522	**0.407***	0.724	-0.172	-0.780	0.256	-0.708	0.650	
3rd WFC	0.787	**0.678***	-0.333	0.438	0.181	-0.774	0.235	-0.616	0.109
	105DAS	112DAS	77DAS	84DAS	91DAS	98DAS	4thWFC	1st WFC	2ndWFC

* = significant at P ≤ 0.05 level. DAS = Days After Sowing; WFC = Week Flower Count.

Table 3. Correlation Matrix of weekly Flower and Mature pods at different harvest date of 'F-Mix' genotype.

105 DAS									
112 DAS	-0.813								
77 DAS	-0.043	-0.440							
84 DAS	-0.037	0.441	-0.175						
91 DAS	0.326	-0.438	-0.282	-0.856					
98 DAS	-0.463	0.749	-0.156	0.902	-0.890				
4th WFC	**-0.258***	0.757	-0.636	0.828	-0.559	0.856			
1st WFC	**-0.709***	0.751	0.149	0.688	-0.893	0.911	0.604		
2nd WFC	**-0.623***	0.808	-0.063	0.803	-0.882	0.979	0.776	0.970	
3rd WFC	**-0.356***	0.801	-0.528	0.856	-0.658	0.920	0.988	0.715	0.861
	105DAS	112DAS	77DAS	84DAS	91DAS	98DAS	4thWFC	1st WFC	2ndWFC

* = significant at P ≤ 0.05 level. DAS = Days After Sowing; WFC = Week Flower Count.

Days to first flowering was not significant among the genotypes. However, 'Kpedevi' and 'F-Mix' varied significantly (P < 0.05) in days to 50% flowering (Table 4).

Table 4. Days to first flowering, and days to 50% flowering of three groundnut genotypes

Genotype	**Days to first flowering**	**Days to 50% flowering**	**Means**
'Chinese'	27	31	29
'Kpedevi'	27	33	20
'F-Mix'	28	35	31.5
Means	27.33	33	
Lsd $_{0.05}$	1.26	1.75	
CV%	2.6	3.10	

IV. Discussion And Conclusion

Yield is dependent to a large extend upon the basic reproductive units available. In groundnut, the basic reproductive units constitute the flowers (Lim and Hamdam, 1984). In this experiment, the days to first flower was 27, 27 and 28 DAS in 'Chinese', 'Kpedevi' and 'F-Mix' varieties respectively. This differ with Ramanatha Rao (1988) who reported that groundnut plants started flowering about 30 - 40 days after planting (DAP). However, the genotypes produced maximum flowers at 6 to 8 weeks after planting, confirming the findings that maximum flower production occurs 6 to 10 weeks after planting (Ramanatha Rao, 1988; Chapin and Thomas, 2004). This further conforms to the findings of Prasad et al. (1999) who reported 28 DAP to be the duration from planting to the respective appearance of the first flower in both the Spanish and Virginia groundnut types.

The variety producing the highest yield ('Kpedevi') was among the varieties, which had the lowest days to 50% flowering, supporting the result of Caliskan et al. (2008) where the highest yield variety had the lowest days to 50 % flowering.

The weekly flower count among the three varieties showed differences especially in the number, pattern and period of production. Ishag (2000) also reported differences in flowering patterns between cultivars. He added that cultivars with a prostrate (Virginia type) growth habit produced more flowers and the total

number of flowers produced varied, ranging from a low of only 18 flowers to a maximum of 142 flowers and suggested that due to the wide variation in flower numbers, the varieties were not significantly different for the number of flowers produced. The Spanish genotype produced fewer flowers than Virginia varieties and this was associated with fewer reproductive nodes and a shorter flower production period. However, there was significant differences among the varieties in number of flowers produced and except for the 'Kpedevi' variety, the 'F-Mix' did not produce more flowers than the 'Chinese' variety though both 'Kpedevi' and 'F-Mix' are Virginia types. Also, the 'Chinese' which is the Spanish variety did not have a shorter flower production period since maximum flowering span from third to fourth week; with more flowers at fourth week than even the 'Kpedevi' genotype though there was no significant difference. In other experiment, the maximum number of flowers opening each day was greater in Spanish cv. ICGV 86015 whilst flower production had effectively stopped by 40 days after flowering in Virginia cv. ICGV 87282. This was in consonance with the data from 'Chinese' genotype where more flowers was produced than the 'F-Mix' but was different in the 'Kpedevi' variety.

The weekly flower count in all the three varieties also showed sporadic flowering pattern from first week to fourth week. There was a low flower number at first week, with a gradual increase to a maximum at second and third week flower count. However, a decrease flower number was observed in fourth week compared to second and third week. Craufurd et al.(2000) suggested that Virginia varieties are generally late flowering and initial rates of flower production are lower than in Spanish varieties and the daily flower production increased progressively with alternations of high and low production, the main flowering period spanned about 40 days after which sporadic flowering were observed. In this study, the initial rate of the Virginia variety ('Kpedevi') was not lower than the Spanish variety ('Chinese') but the Virginia types were later flowering. In addition, flower production increased progressively with two observed peaks: slow production in the first week with increase at second and third week, and later decrease in the fourth week. Generally, there were differences in the number of flowers, and time of flowering among the three varieties grown. Bell et al. (1991) also indicated that groundnut cultivars vary by number of flowers produced.

From this experiment, 'Chinese' and 'Kpedevi' varieties took less number of days to 50% flowering (27 and 27 days respectively). The 'Kpedevi' variety that had more plants flowering daily and days to 50% flowering had more maximum matured pods and this could be critical in determining maximum number of pods at maturity. Rahman and Ali (1970) also indicated that peanut varieties that flower at a rapid rate might produce larger percentage of mature fruits at harvest than variety with slow beginning flowering rates.

However, this may not be responsible for days to which plants may take to reach maturity as this could be genetically controlled, as observed in 'Kpedevi' and 'F-Mix' variety, where 'kpedevi' took less number of days to 50% flowering and had more number of mature pods at maturity, but took longer time to reach maximum pod maturity, contrary to 'F-Mix' which took less days to maximum maturity but had less number of pods and more days to 50% flowering. The 'Chinese' also had more plants flowering daily, and less days to 50% flowering but had less number of matured pods compared to 'Kpedevi' and 'F-Mix'. Though the 'Chinese' took 98 days to reach maximum pod maturity, it also demonstrated its earliness by having more plants flowering daily and less days to first and 50% flowering. Also, the differences in flowering pattern and days to 50% flowering demonstrate variation in flowers and flowering among the groundnut varieties and subsequently maximum pod maturity. Bell et al. (1991) also indicated that, groundnut cultivars vary by number of flowers produced: confirming Craufurd et al. (2000) who associated variation in fruit number to both the timing and the initial rate of flower production.

Awal and Ikeda (2003) suggested the number of flowers, pegs and pods as the most important yield components of groundnut. It is true in this study for both 'Kpedevi' and 'Chinese' genotypes. In 'Kpedevi' genotype at 112 DAS, the number of mature pods plant^{-1} and number of flower count was positively correlated ($r = 0.41$, $r = 0.68$, and $r = 0.33$) at second, third and fourth week respectively. Similarly, number of mature pods and number of flower count was positively correlated at second ($r = 0.16$) and third ($r = 0.21$) week in 'Chinese' genotype at 98 DAS. However, 'F-Mix' at 105 DAS showed a negative correlation with mature pod yield in all the weekly flower count.

Therefore, except in the 'F-Mix' genotype, the maximum number of flowers produced was an indicator of higher number of mature pods in both the 'Chinese' and 'Kpedevi' genotypes. Also, time of flowering at second and third week are critical in ensuring maximum pod yield in 'Kpedevi' and 'Chinese' variety, but time of flowering and number of flowers has little or no effect in influencing maximum pod yield in 'F-Mix' genotype.

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