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Flowering pattern and pod development responses in a spreading type of groundnut (cv. M-13) to a monophenol and aliphatic alcohols mixture

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Abstract. Plants of spreading type of groundnut (*Arachis hypogaea* cv. M-13) were given foliar sprays separately with phenolic compound β-naphthol-1-amino,4-sulphonate (50, 100, 150 μg/ml) and a mixture of aliphatic alcohols—C-24 to C-34 (1 μg/ml) at 30 and 37 days after flowering. In the treated plants, the total number of flowers produced per plant, number of flowers in the initial 3 weeks increased significantly. Both the compounds required lesser number of days for the production of initial 70 flowers as compared with control. With aliphatic alcohols several of the kernel and pod characters increased significantly over the control. Flowering in phase A showed a positive significant correlation with some of the yield characters though it was significantly negatively correlated with harvest index. The compounds were effective in inducing the establishment of early potential sinks and caused efficient mobilization of assimilates for a longer filling period in the pods.

Keywords. Groundnut; flowering; pod development; aliphatic alcohols; phenolic compound.

1. Introduction

Like many other legumes, groundnut has indeterminate growth habit where growth and development of reproduction and vegetative organs overlap. This leads to low fruiting efficiency (12–20%, see Sastry *et al* 1980) due to competition for various metabolites including photosynthates. Yet another constraint in low pod yield is the longer duration of flowering extending up to 120 days, most of which abscise causing low efficiency. Apparently, the flowers produced during the initial 3 weeks after the commencement of flowering would have a better chance of developing into mature pods since these establish relatively more powerful sinks (Hartzook and Goldin 1970; Sengupta and Sharma 1984). Our observation has also shown that later formed flowers failed to attain the pod shape on drying or shrivelling.

Groundnut manifests the problems of diversity in maturing pods due to flower abscission and immature fruit development. To improve the energy economy in groundnut where only 30% of the total pegs develop into mature pods (Patil and Chandra Mouli 1978) with available biomass through the regulation of growth is envisaged. The role of phenolics to determine the level of inhibitors and promotors (Kefeli and Dashek 1984) and physiological manifestations appearing due to exogenous applications of long chain alcohols in different crop species (Ries and Houtz 1983; Menon and Srivastava 1984) have been reported. Therefore, it becomes highly desirable to induce production of maximum number of flowers at the early reproductive stages leading to better availability of potential sinks during early span of reproductive phase. Role of phenolics (Nanda *et al* 1976; Cleland and Ben-tal 1982; Tayal and Sharma 1982; Khurana and Maheshwari 1986) and aliphatic alcohols in

flowering (Ries and Houtz 1983; Menon and Srivastava 1984) has been established. With these objective, the total (cumulative) number of flowers produced per plant and the pattern of flowering as affected by foliar applications of monophenols and aliphatic alcohols was studied. Attempts were also made to ascertain whether the pattern of flowering was related to pod development and yield under field conditions.

2. Materials and methods

Groundnut cultivar (spreading type) cv. M-13 was sown on July 1, 1985 in the field area of the University in a randomized block design with 3 replications of each treatment. Each plot measured 3·6 × 1·8 m with the recommended spacing for plants and rows. Crop was raised according to the Package of Practices PAU, Ludhiana (1984–85) for fertilizer application, irrigation, etc.

Foliar sprays separately with the two compounds (i) at flower initiation stage were applied (30 days after sowing) followed by another spray after one week and (ii) gynophore initiation stage (42 days after sowing) followed by another spray after 7 days interval. During foliar spray applications 0·85 triton X-80 was added to each solution as surfactant. Following notations are used for different treatments.

C	Control (water)
I_{F50}	1,2,4-acid (50 μg/ml) at flower initiation stage
I_{F100}	1,2,4-acid (100 μg/ml) –„–
I_{F150}	1,2,4-acid (150 μg/ml) –„–
I_{G50}	1,2,4-acid (50 μg/ml) at gynophore initiation stage
I_{G100}	1,2,4-acid (100 μg/ml) –„–
I_{G150}	1,2,4-acid (150 μg/ml) –„–
A_{F1}	Aliphatic alcohols mixture (1 μg/ml) at flower initiation stage
A_{G1}	Aliphatic alcohols mixture (1 μg/ml) at gynophore initiation stage

2.1 *Chemistry of plant growth regulators used*

	Common name	Chemical name		
Monophenol	1,2,4-acid	β-naphthol-1-amino, 4-sulphonate		%
Aliphatic alcohols	'Mixtalol'	C-24 tetracosanol	:	6–10
		C-26 hexacosanol	:	12–16
		C-28 octacosanol	:	15–20
		C-30 triacontanol	:	24–30
		C-32 dotriacontanol	:	11–14
		C-34 tetratriacontanol	:	4–5

Monophenol was obtained from Gem dyes, Ludhiana and aliphatic alcohols from Hindustan Levers Ltd., Bombay.

2.2 *Cumulative flower production*

From each plot, 5 plants were tagged to record the flowering data. The total

number of flowers produced per plant was recorded by counting the number of flowers produced daily for 10 weeks from the day the first flower appeared. The days taken for the first 70 flowers to appear were also computed. The total span of flowering was divided into 3 phases: Phase A (0–3 weeks DAF), Phase B (4–6 weeks DAF) and Phase C (7–10 weeks DAF). The ratio of flowers in phases A–C was also computed. The 70 flowers count was decided with the objective to observe synchrony in flowering since the average number of developed and underdeveloped cumulative pods at the time of harvest per plant was around 70 in most cases.

2.3 *Mature pods*

Total number of pods at 130 DAS/harvest time from the randomly selected plants from each plot was recorded. The weight of pods (g)/plant was taken at 130 DAS.

2.4 *Seeds*

Pods from the 5 randomly selected plants per replication were taken to record the data on number of seeds per pod. After harvest, the kernels were separated from the pods. One hundred kernels were taken from each replicate randomly and their weight was recorded in g.

2.5 *Seed yield*

Seed yield at harvest time was recorded from the net area (3·6 × 1·8 m) and expressed as kg/ha.

2.6 *Shelling per cent*

The shelling per cent was calculated as under:

$$\frac{\text{Weight of kernels}}{\text{Weight of pods}} \times 100.$$

2.7 *Harvest index*

Harvest index (HI) was calculated after harvest:

$$\frac{\text{Weight of pods}}{\text{Weight of total plant}} \times 100.$$

The data on different flower and seed characters were subjected to statistical analysis by computing correlation coefficient as the product-movement correlation between them.

3. Results

3.1 *Flowering behaviour*

The first flower appeared on 30–32 days after sowing and flowering continued up to 14 weeks thereafter in control. The total (cumulative) number of flowers formed per

plant on the average ranged up to 180 in the control with a peak of flowering observed during phase B. Further, the number of flowers formed per day started decreasing after 6 weeks of flower initiation. Significant differences were recorded between the number of flowers formed during the 3 phases (table 1).

The data from table 1 show significant differences among the different treatments, different stages of observations and some of the interactions effects for this trait were also significant.

The number of flowers in phase A increased to maximum with two concentrations of 1,2,4-acid (50 and 100 μg/ml) sprayed during flowering stage as compared with other treatments over the control (76·3 and 77 as against 56 in control).

The tests of significance on the number of flowers in phase B also recorded similar trend as observed for the number of flowers in phase A, except that the treatment × stage interaction at lower concentration which was significant in phase A became non-significant during phase B. The number of flowers was maximum with aliphatic alcohols (A_{F1}) during this stage, followed by I_{F50} during the flowering stage in comparison to the control (98 and 97 against 81 in control). With A_{F1}, the number of flowers was least (26·3), whereas I_{G100} produced maximum number of flowers (42).

3.2 *Total number of flowers*

Table 1 shows data on the analysis of variance indicating significant differences among the treatments and stages. I_{F50} treatment produced maximum number of flowers (204·3).

The minimum number of days taken for the first 70 flowers to appear was significantly affected by different treatments and stages (table 1). Maximum decrease in number of days (18·7) for the first 70 flowers formation was observed in I_{F100} treated plants against 23 days in control.

3.3 *Number of mature pods*

The analysis of variance showed significant differences among the different concentrations and stages for the number of mature pods (table 2). All the

Table 1. Effect of foliar spray applications with 1,2,4-acid (50, 100 and 150 μg/ml) and mixture of aliphatic alcohols (1 μg/ml) on flowering behaviour in peanut variety M-13.

Treatment	Number of flowers in phase			Minimum days for 70 flowers to open	Total number of flowers
	A	B	C		
Control	56·0	81·0	39·0	23·3	176·0
I_{F50}	76·3	97·0	31·0	20·0	204·3
I_{G50}	62·0	88·3	38·0	22·0	185·7
I_{F100}	77·0	92·3	31·0	18·7	200·0
I_{G100}	58·0	86·0	42·0	23·0	179·3
I_{F150}	65·6	88·0	35·0	21·0	188·7
I_{G150}	59·0	82·3	38·0	23·3	176·0
A_{F1}	64·0	98·0	27·3	22·0	189·3
A_{G1}	57·0	92·0	35·0	23·0	175·0
CD at 5%	9·5	10·7	7·8	1·7	16·7

Table 2. Effect of foliar spray applications with 1, 2, 4-acid (50, 100 and 150 μg/ml) and mixture of aliphatic alcohols (1 μg/ml) on some seed characteristics of peanut variety M-13.

Treatment	Number of kernels plant^{-1}	Weight of kernels plant^{-1}(g)	100-kernel weight(g)	Number of pods plant^{-1}	Weight of pods(g) plant^{-1}	Number of mature pods plant^{-1}	Yield (kg/ha)	HI (%)	Shelling (%)
Control	56·5	28·5	61·0	43·1	44·5	24·9	2210	26·0	64·3
I_{F50}	73·0	34·6	61·9	46·5	49·8	28·0	2640	31·4	79·7
I_{G50}	67·3	38·0	62·7	51·7	52·5	26·7	2410	33·0	71·4
I_{F100}	68·0	34·3	63·1	38·8	45·9	28·3	2540	30·3	74·1
I_{G100}	61·0	34·1	65·1	39·3	52·5	24·9	2450	33·8	69·5
I_{F150}	65·3	32·2	58·9	50·6	45·9	25·4	2540	30·7	68·6
I_{G150}	64·1	33·3	61·6	43·9	44·4	24·9	2480	31·2	74·7
A_{F1}	78·1	38·6	64·9	61·3	53·2	31·1	2680	32·9	68·1
A_{G1}	65·1	32·9	69·1	58·0	52·9	28·7	2410	31·7	62·2
CD at 5%	5·2	4·7	3·8	17·7	8·3	3·8	250	—	—

interaction effects were also having significant effect on the number of mature pods. Data in table 2 indicate significant differences among the concentrations and stages. Treatment A_{F1} caused maximum increase for this trait (61·3) over the control (43·1).

3.4 *Number and weight of kernels/plant*

Table 2 shows that all the factors, viz. concentrations, stages of application and their interactions significantly affected the number of kernels per plant. Maximum number of kernels (78·1) were observed in A_{F1} against 56·5 in control. The weight of seeds/plant differed significantly with concentrations and stages of application (table 2), maximum being with A_{F1} treatment.

3.5 *100-kernel weight*

100-kernel weight was maximum in A_{G1} (69·1 g) as compared to control (61 g).

3.6 *Weight of pods/plant and yield*

Weight of pods per plant increased to maximum in A_{F1} (53·2) followed by A_{G1} (52·9) which was significantly more than control (44·5), whereas yield was maximum in A_{F1} (2680 kg/ha) followed by I_{F50} (2640 kg/ha) as compared to control (2210 kg/ha).

3.7 *HI*

The HI in the spraying experiment enhanced from 26 for the control to 33·8 for I_{G100}, followed by 33 for I_{G50} and 32·9 for A_{F1}. Shelling percentage enhanced from 64·3 for the control to 79·7 for I_{F50}, followed by 74·7 for I_{G150}.

The perusal of data in table 3 revealed that yield, HI and 100-kernel weight were positively correlated with height of the plant. The yield characteristics were negatively correlated with total weight of the plant.

4. Discussion

In our studies, a general lack of significant correlation between the cumulative flowers produced and the number of mature pods at the time of harvest indicates

Table 3. Correlation coefficient among different flower and seed characters with yield parameters in peanut variety M-13.

Character	Yield characters			
	Yield	HI	Shelling (%)	100-kernel weight
Flowers in phase A	0·479	0·663	0·307	0·613
Flowers in phase B	0·296	0·218	−0·030	0·374
Flowers in phase C	0·087	−0·388	−0·274	0·296
Days taken for 70 flowers	−0·451	−0·625	−0·088	−0·173
Total number of flowers	0·477	0·437	0·034	0·161
Weight of pods	0·433	−0·007	−0·336	0·609
Number of mature pods	0·129	0·794	0·416	−0·137
Number of seeds	0·146	0·418	0·216	−0·064
Weight of seeds	0·546	0·157	−0·033	0·595

that the total number of flowers does not act as productivity determinant. On the contrary, a positive correlation has been computed between the number of flowers produced during the phase A and yield. The number of days required for 70 flowers to acquire anthesis during the early stage of reproductive growth was significantly related with productivity. Thus, the treatments which took lesser days to produce 70 flowers showed significant positive correlation with pod weight and yield. A highly negative significant correlation between the number of days to produce 70 flowers and yield suggested that plant growth regulators could be successfully employed to facilitate the synchronous development of pods by initiating the process early in the reproductive phase, giving a longer filling period to the developing pods.

In M-13 cultivar, the potential pod number is established during 35–40 days after the initiation of first flower. Obviously, synchrony in pod development and availability of continuous supply of assimilates at this stage due to overlapping of vegetative growth with reproductive phase regulate the number of potential pods. Our observations have established the fact that most of the mature pods develop from the initially formed flowers which initiate peg formation earlier. The period of flowering in the control extends up to 98 days after flowering. Present studies also point towards the need to curtail number of flowers, especially during phase C which would be beneficial for increasing yield. Pods formed later remained juvenile or immature. Although assimilates produced by the plant were the same, these were not available and/or efficiently utilized by these pods and hence did not contribute to the productivity. In fact, the juvenile pods utilized some of the assimilates at the cost of potential mature pods, thereby causing reduction in yield.

We also examined the relationship between early establishment of powerful sinks (flowers in phase A) and flowers in phase C (A/C ratio). This ratio was significantly correlated with yield. Obviously, the establishment of early potential sinks directed the assimilates from vegetative to reproductive parts. In fact, we recorded a decrease in weight of vegetative parts in some treatments and this trend was negatively correlated with weight of pods and seeds (Usha 1987). Some aspect of this disparity might be attributed to remobilization of assimilates to the growing pods. Menon and Srivastava (1984) and Nanda *et al* (1985) have suggested role of aliphatic alcohols and phenolics, respectively in causing rapid mobilization of assimilates (Malik *et al* 1986). We also noticed a positive correlation between minimum days

for first 70 flowers to open and increase in exceptionally large kernels (ELK) percentage. Clearly, the duration of the filling period for pods with these compounds is enhanced. Also, ovules development began earlier resulting in the enhancement of capacity of the sink. Thus, increase in the duration of the filling period and rapid transport of assimilates by some of the PGR's aided enhancement of ELK per cent. Present studies demonstrate that some of the treatments set ideal conditions for ELK formation. In this context A/C ratio assumes greatest relevance since the number of potential pods per plant is decided within 70 days of sowing. We attribute this to differential flowering factor (DFF) or A/C ratio for flowering in this spreading type of groundnut. It may be added here that earlier formed flowers in this variety can initiate gynophores earlier, thereby leading to early penetration in the soil and subsequent peg and pod formation. This stage has no shortage of assimilates (source being at a very active stage) and interorgan competition for the nutrients and photosynthates (Sastry *et al* 1985) which causes reduction in podding efficiency might also be curtailed at this stage.

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