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# Synchronization of flowering of diverse genotypes of pigeonpea (*Cajanus cajan* L. Millsp.) by plant growth regulators and nutrients

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## Abstract

**Synchronization in flowering of diverse genotypes of pigeonpea was studied by using eight chemicals. It was found that Ethrel, MH, NAA, and $KNO_3$ delayed the flowering while GA, BA and $K_2H_2PO_4$ hastened the flowering in all genotypes. Maximum delay in days to 50% flowering by 15.1 days was observed with 0.02% Ethrel while maximum acceleration of flowering by 13.5 days was accomplished with 0.01% GA. Synchronization of flowering between untreated male-sterile lines with the treated pollinator lines was achieved in the present study.**

**Key Words :** Pigeonpea, plant growth regulators, nutrients, flowering synchronization

## Introduction

Synchronization of flowering of diverse parental lines is considered to be one of the main objectives of seed production research in pigeonpea since a number of male-sterile lines and diverse genotypes as pollinators are available and are characterised by different flowering duration. A range of variability of 55 to 237 days has been observed in diverse genotypes of pigeonpea for days to 50 per cent flowering [1] and heterotic hybrid combinations have been realised between different maturity groups [2]. The diversity in flowering poses problems in producing the hybrids. In order to accelerate the experimental hybrid seed production, synchronization of flowering among diverse genotypes is obviously an essential pre-requisite. Keeping the above fact under consideration, a preliminary investigation on the manipulation of flowering duration by plant growth regulators and nutrients was carried-out in pigeonpea.

## Materials and methods

An experiment was conducted in a split-plot design with 3 replications involving six genotypes (Two female parents i.e., MS Prabhat DT, QMS-1 and four pollinator lines i.e., Pusa 856, Pusa 606, Pusa 84 and 89-7-16 designated respectively as $V_1$-$V_6$) as main-plots and seventeen treatments comprising of 8 chemicals Maleic hydrazide (MH), Napthalene accetic acid (NAA), Ethrel, gibberatic Acid (GA), Urea, Boric acid (BA), Pottasium nitrate ($KNO_3$) and Pottasium dihydrogen phosphate ($K_2H_2PO_4$) each at two concentrations with one control as sub-plot treatments. Each treatment was sown in a four row plot of 4m length with 30 cm × 15 cm as inter and intra-row spacings. Foliar application of plant growth regulators and nutrients was given at 50 days after sowing (DAS) followed by subsequent two sprays at 15 days interval. The observations were recorded on plot basis on five phenological characters viz. number of days from date of sowing to days to flower bud initiation, days to first flower, days to 50% flowering, days to end of flowering and days to maturity and the data were subjected to statistical analysis as per standard procedures [3].

## Results and discussion

Significant differences in the flowering behaviour of varieties, in effects of treatments on varieties and their interaction for five phenological characters were observed suggesting that flowering and maturity can be manipulated by different plant growth regulators and nutrients in different genotypes (Table 1). The variation in the genotypes for all flowering characters revealed that QMS-1 was the earliest while Pusa 84 was the latest in flowering and maturity (Table 2). The flower bud initiation was delayed to the maximum extent by 12 days with 0.02% Ethrel in case of MS Prabhat DT. In general, Ethrel, Maleic hydrazide, Naphthalene acetic acid, Urea and Potassium nitrate) at both concentrations delayed flower bud initiation in all the genotypes. On the contrary, Boric acid, Gibberellic acid and Potassium dihydrogen phosphate at both concentrations accelerated the flower bud initiation. Maxiumum delay of flower bud initiation by 9.1 days while maximum acceleration by 6.7 days was accomplished with 0.02% Ethrel and 1.0% BA treatments, respectively. Similar findings of delayed floral initiation by MH and Ethrel application have been reported in sorghum [4] and peanut [5].

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**Table 1.** Analysis of variance for split-plot design for five phenological characters in pigeonpea.

| Source | D.F. | Mean sum of squares | | | | |
|---|---|---|---|---|---|---|
| | | Days to flower bud initiation | Days to first flower | Days to 50% flowering | Days to end of flowering | Days to maturity |
| Replications | 2 | 7.94 | 7.88 | 14.75 | 16.75 | 22.75* |
| Varieties | 5 | 5815.45** | 6417.05** | 5483.90** | 6497.50** | 5778.90** |
| Error (a) | 10 | 20.55 | 15.58 | 14.20 | 7.45 | 4.85 |
| Treatments | 16 | 495.61** | 912.33** | 1484.84** | 1203.47** | 1308.25** |
| Varieties × treatments | 80 | 6.17** | 17.46** | 21.18** | 28.39** | 29.85** |
| Error (b) | 192 | 0.79 | 1.04 | 1.50 | 1.57 | 2.55 |

*Significant at 5% level; **Significant at 1% level

**Table 2.** Effect of plant growth regulators and nutrients on five phenological characters in pigeonpea

| Treatment & Concentration (%) | Days to flower bud initiation | | | | | | Mean | Days to first flower | | | | | | Mean | Days to 50% flowering | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | |
| MH 0.01 | 83.7 | 72.7 | 73.7 | 86.0 | 101.7 | 77.3 | 82.5 | 96.0 | 86.0 | 90.3 | 97.0 | 119.0 | 89.3 | 96.3 | 106.3 | 97.7 | 103.7 | 107.7 | 127.0 | 101.0 | 107.2 |
| MH 0.02 | 85.0 | 75.0 | 75.0 | 87.0 | 103.3 | 79.0 | 84.0 | 97.3 | 89.3 | 93.7 | 98.7 | 121.3 | 93.0 | 98.9 | 108.7 | 102.3 | 107.7 | 109.3 | 131.3 | 105.3 | 110.8 |
| NAA 0.01 | 83.3 | 72.0 | 73.3 | 85.0 | 100.7 | 77.3 | 81.9 | 84.0 | 85.7 | 89.7 | 97.0 | 117.7 | 89.7 | 93.9 | 94.3 | 96.7 | 103.3 | 106.3 | 126.0 | 101.0 | 104.6 |
| NAA 0.02 | 84.3 | 74.0 | 74.7 | 87.0 | 101.7 | 78.0 | 83.3 | 96.0 | 88.0 | 93.0 | 98.7 | 118.7 | 91.7 | 97.7 | 107.0 | 100.3 | 106.3 | 109.0 | 129.0 | 103.0 | 109.1 |
| Ethrel0.01 | 88.0 | 76.0 | 77.3 | 86.7 | 102.7 | 79.3 | 85.0 | 77.3 | 93.3 | 94.3 | 98.7 | 119.7 | 93.3 | 99.4 | 109.7 | 105.0 | 108.7 | 109.3 | 129.0 | 105.0 | 111.1 |
| Ethrel0.02 | 90.0 | 77.0 | 78.7 | 87.3 | 104.3 | 80.3 | 86.3 | 100.0 | 95.3 | 98.3 | 100.0 | 123.0 | 96.0 | 102.1 | 112.0 | 107.0 | 111.7 | 111.0 | 134.0 | 109.3 | 114.2 |
| GA 0.005 | 73.3 | 60.0 | 66.0 | 76.0 | 92.7 | 69.0 | 72.8 | 80.0 | 70.0 | 79.3 | 83.7 | 105.7 | 78.7 | 82.9 | 86.3 | 78.0 | 88.3 | 86.3 | 112.0 | 88.0 | 89.8 |
| GA 0.01 | 71.0 | 58.0 | 66.7 | 74.0 | 90.0 | 69.7 | 71.2 | 77.3 | 67.3 | 89.0 | 81.3 | 100.3 | 75.3 | 81.8 | 83.0 | 75.0 | 78.3 | 86.3 | 106.7 | 84.0 | 85.6 |
| Urea 1.0 | 81.7 | 69.0 | 72.3 | 80.0 | 93.7 | 70.0 | 77.8 | 90.7 | 81.0 | 88.0 | 89.0 | 108.0 | 80.0 | 89.4 | 98.3 | 91.3 | 99.7 | 97.3 | 116.7 | 99.0 | 98.7 |
| Urea 2.0 | 83.7 | 70.0 | 74.3 | 84.7 | 99.3 | 74.7 | 81.1 | 91.7 | 83.3 | 90.7 | 95.3 | 114.0 | 86.0 | 93.5 | 100.7 | 92.0 | 113.3 | 104.7 | 123.3 | 97.3 | 105.2 |
| BA 0.5 | 71.3 | 59.3 | 65.0 | 75.3 | 92.7 | 67.3 | 71.8 | 78.7 | 69.0 | 77.7 | 84.0 | 106.0 | 76.7 | 82.0 | 86.7 | 76.7 | 88.3 | 90.0 | 112.0 | 95.0 | 91.4 |
| BA 1.0 | 69.7 | 57.7 | 64.0 | 74.0 | 91.3 | 66.3 | 70.5 | 76.3 | 67.3 | 76.0 | 81.3 | 102.3 | 75.0 | 79.7 | 83.0 | 75.0 | 86.0 | 86.7 | 107.7 | 83.0 | 86.9 |
| $KNO_3$ 1.0 | 80.0 | 63.7 | 72.7 | 84.0 | 98.7 | 75.0 | 79.0 | 90.3 | 74.3 | 87.0 | 93.7 | 112.3 | 87.0 | 90.8 | 100.0 | 84.7 | 99.3 | 102.0 | 121.3 | 97.0 | 100.7 |
| $KNO_3$ 2.0 | 81.0 | 67.3 | 72.3 | 85.0 | 99.3 | 76.3 | 80.4 | 90.0 | 80.0 | 89.0 | 96.0 | 112.7 | 90.0 | 92.9 | 100.0 | 90.3 | 100.7 | 105.7 | 122.0 | 99.0 | 102.9 |
| $K_2H_2PO_4$1.0 | 75.7 | 63.0 | 67.0 | 78.0 | 93.7 | 69.0 | 74.4 | 84.0 | 74.3 | 82.3 | 96.3 | 107.0 | 77.0 | 85.2 | 92.3 | 84.3 | 93.7 | 93.3 | 112.3 | 87.0 | 93.8 |
| $K_2H_2PO_4$ 2.0 | 74.0 | 61.3 | 65.7 | 76.0 | 91.0 | 68.0 | 72.7 | 82.0 | 71.3 | 79.0 | 83.3 | 103.7 | 76.7 | 82.7 | 88.3 | 80.3 | 90.0 | 89.7 | 110.3 | 85.0 | 90.6 |
| Control | 78.0 | 66.0 | 69.3 | 81.3 | 96.0 | 72.7 | 72.2 | 89.0 | 77.3 | 84.3 | 91.7 | 111.3 | 84.0 | 89.6 | 98.0 | 86.3 | 97.3 | 99.7 | 119.0 | 94.0 | 99.1 |
| Mean | 79.6 | 67.4 | 71.1 | 81.6 | 97.2 | 73.4 | 78.4 | 88.3 | 79.6 | 87.2 | 91.5 | 111.9 | 84.7 | 90.5 | 97.0 | 89.6 | 98.6 | 99.7 | 120.0 | 95.5 | 100.1 |
| CD at 5% | Varieties | | | 1.91 | | | | | | | 1.67 | | | | | | | 1.59 | | | |
| | Treatments | | | 0.60 | | | | | | | 0.69 | | | | | | | 0.82 | | | |
| | Var.xTreat. | | | 1.47 | | | | | | | 1.68 | | | | | | | 2.02 | | | |

**Table 2. (Contd.)**

| Treatment & Concentration (%) | Days to end of flowering | | | | | | Mean | Days to maturity | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | |
| MH 0.01 | 114.3 | 108.7 | 114.3 | 119.0 | 136.7 | 109.0 | 117.0 | 154.0 | 148.3 | 159.3 | 156.3 | 173.7 | 144.0 | 155.9 |
| MH 0.02 | 115.7 | 113.3 | 116.7 | 121.0 | 141.7 | 114.0 | 120.4 | 153.7 | 152.7 | 162.7 | 158.0 | 177.0 | 146.7 | 158.4 |
| NAA 0.01 | 103.3 | 107.0 | 115.7 | 118.3 | 138.0 | 110.0 | 115.4 | 143.3 | 145.7 | 161.0 | 158.7 | 163.0 | 146.0 | 152.9 |
| NAA 0.02 | 115.0 | 112.3 | 116.7 | 122.7 | 141.0 | 111.7 | 119.9 | 153.3 | 152.3 | 162.0 | 162.0 | 177.3 | 150.0 | 159.5 |
| Ethrel 0.01 | 117.7 | 115.7 | 119.3 | 120.7 | 138.7 | 113.3 | 120.9 | 155.7 | 154.7 | 166.0 | 157.3 | 174.3 | 151.0 | 159.8 |
| Ethrel 0.02 | 120.0 | 118.3 | 121.7 | 122.7 | 142.7 | 116.3 | 123.6 | 156.7 | 156.7 | 168.7 | 159.3 | 180.0 | 154.3 | 162.6 |
| GA 0.05 | 98.3 | 87.7 | 101.3 | 100.7 | 124.7 | 98.0 | 101.8 | 137.7 | 125.7 | 144.7 | 137.3 | 161.7 | 131.0 | 139.7 |
| GA 0.01 | 96.7 | 83.0 | 93.0 | 97.3 | 122.0 | 96.0 | 98.0 | 135.0 | 122.7 | 141.7 | 136.3 | 156.0 | 129.0 | 136.8 |
| Urea 1.0 | 107.3 | 101.0 | 113.6 | 108.3 | 131.0 | 97.7 | 109.8 | 146.3 | 140.0 | 157.7 | 148.0 | 165.3 | 131.3 | 148.1 |
| Urea 2.0 | 110.0 | 103.0 | 122.7 | 114.7 | 135.3 | 107.7 | 115.6 | 150.0 | 142.3 | 163.0 | 156.0 | 171.7 | 144.0 | 154.5 |
| BA 0.5 | 108.7 | 86.0 | 120.0 | 102.0 | 124.0 | 101.7 | 104.1 | 147.3 | 127.3 | 143.7 | 141.0 | 158.7 | 134.0 | 142.0 |
| BA 1.0 | 95.3 | 83.7 | 100.7 | 100.7 | 122.7 | 92.0 | 99.2 | 136.0 | 123.3 | 142.3 | 139.3 | 155.0 | 127.0 | 137.2 |
| $KNO_3$ 1.0 | 111.7 | 95.3 | 112.0 | 112.7 | 135.0 | 107.7 | 112.4 | 152.0 | 135.7 | 157.0 | 154.7 | 172.0 | 142.3 | 152.3 |
| $KNO_3$ 2.0 | 111.3 | 101.0 | 111.7 | 117.7 | 137.0 | 110.7 | 114.9 | 152.3 | 140.0 | 155.5 | 157.3 | 175.0 | 147.0 | 154.5 |
| $K_2H_2PO_4$ 1.0 | 103.7 | 93.3 | 105.7 | 104.7 | 125.3 | 97.7 | 105.0 | 142.3 | 134.3 | 148.0 | 141.0 | 166.3 | 132.0 | 144.0 |
| $K_2H_2PO_4$ 2.0 | 100.0 | 88.7 | 103.0 | 100.7 | 125.3 | 97.0 | 102.4 | 137.0 | 130.0 | 144.7 | 137.7 | 158.3 | 130.7 | 139.7 |
| Control | 108.0 | 96.7 | 109.3 | 110.0 | 132.0 | 103.7 | 109.9 | 148.3 | 134.0 | 153.3 | 150.0 | 167.3 | 138.0 | 148.5 |
| Mean (Var) | 108.6 | 99.7 | 110.5 | 111.4 | 132.5 | 104.9 | 111.3 | 147.3 | 139.2 | 154.8 | 150.0 | 167.8 | 139.9 | 149.8 |
| CD at 5% | Varieties | | | | | 1.15 | | | | | | | 0.93 | |
| | Treatment | | | | | 0.84 | | | | | | | 1.08 | |
| | Var. x Treat. | | | | | 2.07 | | | | | | | 2.63 | |

$V_1$ (M S Prabhat DT) $V_2$ (QMS-1) $V_3$ (Pusa 856) $V_4$ (Pusa 606) $V_5$ (Pusa 84) $V_6$ (89-7-16)

A difference of 32.3 days (averaged over treatments) in first flower appearance was observed between the earliest and late flowering parents (Table 2). The results indicate that 0.02% Ethrel was effective for delaying the first flower appearance by 12.5 days while 1.0% BA was effective for hastening the flower appearance by 9.9 days over all the genotypes. Days to first flower appearance was delayed to the maximum by 18 days with 0.02% Ethrel in QMS-1 while hastening in days to first flower by 12.7 days was achieved with 1.0% BA in MS Prabhat DT.

Days to 50 percent flowering was delayed by 20.7 days with 0.02% Ethrel in QMS-2 while maximum decrease in time to flowering by 19.0 days was noticed with 0.01% GA in Pusa 856. Induced early flowering with foliar application of GA has earlier been reported in peas [6], soybean [7] and groundnut [8]. Application of GA followed by 1% Boron induced early flowering in siratro [9] and in rice [10].

The characters, days to end of flowering and days to maturity, do not seem to have the direct effect on the flowering synchronization. However, the increase in days to end of flowering indicates prolonged flowering duration in a genotype. The flowering duration was extended to the maximum by 21.6 days in QMS-1 with 0.02% Ethrel while it was shortened by 16.3 days with 0.01% in Pusa 856 indicating that QMS-1 and Pusa 856 were more sensitive to the delaying and hastening treatments, respectively.

### *Synchronization between male-steriles and pollen parents*

Synchronization in days to first flower was observed between untreated MS Prabhat DT and 0.01% GA and 2.0% $KNO_3$ treated plants in Pusa 856, 1.0% urea treated plants in Pusa 606, 0.01% MH treated plants in 89-7-16 and between 0.02% Ethrel treated, MS Prabhat DT and 0.01% GA treated Pusa 84 suggesting that flower initiation can be hastened by application of 0.01% GA in the late flowering parents or delayed by treating with 0.02% Ethrel, 2.0% $KNO_3$, 0.01% MH or 1.0% Urea spray in the early flowering parents.

A persual of the effect of treatments on the behaviour of parental lines for days to 50% flowering revealed that flowering in untreated MS Prabhat DT and QMS-1 were synchronized with that of 1.0% BA treated Pusa 856, 0.005% and 0.01% GA treated plants in Pusa 606, 0.01% GA and 2.0% $K_2H_2PO_4$ in 89-7-16. Besides, synchrony was observed between 0.02% Ethrel treated QMS-1 and 0.01% GA treated plants in Pusa 84. Similarly, spraying of 1.0% $K_2H_2PO_4$ to the early flowering seed parent QMS-1 and 0.01% GA to the late flowering male parent 89-7-16 was found to be effective for achieving synchronization between them.

From the foregoing discussion, it is concluded that there is vast scope for the use of growth regulators and nutrient sprays in pigeonpea for achieving proper nicking between diverse genotypes varying in flowering duration. It also identified 0.02% Ethrel as the best treatment for delaying while 0.01% GA and 1.0% BA as the best treatments for inducing earliness among the parental lines in a hybrid seed production programme. However, the information on the adverse effect of growth retardants viz., Ethrel, MH and NAA on yield and its components needs to be further investigated before advocating the use of these chemicals for large scale commercial hybrid seed production. It is also suggested that further investigation on the possibility of reducing the time of application from three to two or one spray should be explored.

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