Changes in some major elements associated with feminization of castor (**Ricinus communis** L.) influenced by kinetin and morphactin*

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COMPENDIO

Se ha estudiado el efecto de cinetina y morfactina sobre la expresión sexual floral del ricino (Ricinus communis *L. cv 'Aruna'). Se observó que la proporción de flores femeninas a masculinos fue de 1: 4,75 en las plantas testigo, de 1: 1,61 en las tratadas con cinetina, y de 1: 3,29 las con morfactina. Aunque el número de flores masculinas aumentó en las plantas tratadas con morfactina, la proporción entre los sexos no se alteró mucho ya que no hubo disminución de flores masculinas. Comparado con el testigo, la altura del tallo disminuyó y el número de nudos aumentó con el tratamiento de morfactina, mientras que la altura y el número de nudos aumentó con la cinetina.*

Se discute la modificación de la expresión sexual con respecto a las fracciones del fósforo y algunos elementos minerales. El P-total, el P-inorgánico, P-ácido nucleico y P- proteína, se incrementaron, mientras que el P-lípido disminuyó con los tratamientos de cinetina y morfactina, comparados con el testigo. Los contenidos de sodio, potasio y calcio fueron favorecidos por ambas tratamientos. Las flores masculinas se caracterizaron por niveles más altos de P- total y P-inorgánico, y las flores femeninas, por niveles más altos de P-orgánico, P-lípido y P-ácido nucleico. Los contenidos de potasio y calcio fueron más altos en las flores masculinas, y el sodio más alto en las flores femeninas. El incremento de la feminización fue causada tanto por la cinetina como por la morfactina, más en la primera que en la segunda. Así la morfactina se comportó en forma similar que la cinetina.

Introduction

MORPHACTINS have been used by several workers to elucidate their effects on flowering and sex expression in various flowering plants (22) Morphactins significantly affect sex expression in some cucurbits (3, 9, 20) and increases male tendency in *Luffa acutangula* (4, 10). Induction of feminization has been reported by treatments with cytokinins (5, 8, 16). The effect of growth regulators on the physiology of sex expression in monoecious plants is scanty, hence the present investigation is designed to study the effects of kinetin and morphactin on sex expression in castor. One approach for the understanding of the mechanism of flowering and sex expression in higher plants is to study the endogenous changes of metabolites during the process of feminization. Changes in some major elements such as phosphorus, calcium, sodium and potassium are presented and discussed in the present study.

Materials and Methods

Castor *(Ricinus communis* L.) is an important oil crop, and is widely grown in tropical, sub tropical and temperate countries 'Aruna', a radiation induced mutant has dwarf habit and relatively early maturity. It has a non-shattering spike, so it has been chosen for the present study. The seeds were sown in homogenously manured plots. The plants reached anthesis

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stage eleven weeks after sowing. The shoot tips were collected at the following stages in control and treated plants and were used for chemical analysis.

Sampling stages

Stage 1: Seedlings, two weeks after sowing

Stage 2: Plants, four weeks after sowing

Stage 3: Plants, six weeks after sowing

Stage 4: Plants, eight weeks after sowing

Stage 5: Plants, nine weeks after sowing. This is the critical vegetative stage where the shoot tip begins to transform itself into reproductive bud

Stage 6: Plants, ten weeks after sowing. This is the critical reproductive stage where the shoot tip was transformed from vegetative to reproductive bud containing minute male and female flowers in its sheath.

Stage 7: Plants, eleven weeks after sowing. This is the anthesis stage where the terminal racemose inflorescence shows anthesized male flowers and well differentiated female flowers.

Treatments

Kinetin (6-furfurylaminopurine) and morphactin EMD 7301 W (methyl ester of chlorfluerenol) were used at a concentration of 20 ppm each. The aqueous solutions of the chemicals with 0.01% wetting agent (Tween-20) were sprayed at stage 3 and 4 to the stem tips and fully expanded upper leaves of the plant. Distilled water with wetting agent was sprayed for the control plants. Separate plots were maintained for each treatment.

Inflorescences at the seventh stage were removed from control and treated plants and the number of female and male flowers were counted. The flower sex ratio was calculated. The number of nodes and height of the plants were also noted. The acid soluble inorganic, lipid, nucleic acid and protein phosphorus were extracted by the procedure of Hall and Hodges (7) and then the orthophosphates were estimated by the method of Fiske and Subba Row modified by Bartlett (1). Difference between the total and acid soluble inorganic phosphorus gives the organic phosphorus. Sodium, potassium and calcium were estimated by using flame photometric methods (18).

Results and Discussion

Sex expression

The proportion of pistillate to staminate flowers has been used as an index of sex expression. It was observed that the ratio of pistillate to staminate flowers in control plants was 1:4.75. There was an increase of 78.13% over control with kinetin treatment and 41.63% with morphactin treatment in femaleness. The pistillate: staminate ratio was as follows — control 1 : 4.75, kinetin 1 : 1.61, and morphactin 1 : 3.29 (Table 1). With morphactin treatment, the reduction in maleness was only 3% but the increase in femaleness was 40% hence the ratio of pistillate to staminate was not significantly altered in relation to control plants. As opposed to this behaviour, kinetin reduced the maleness by 40% and increased femaleness by 78% and hence the ratio of pistillate to staminate was significantly altered. The flower sex expression was analysed statistically. The values for critical difference (C. D.) were calculated at 5% level when they became significant. In the case of female flowers, the C.D. values showed highly significant differences between control and treatments. There was significant difference between control and kinetin but the results were insignificant between control and morphactin treatments in the case of male flowers. Increase in femaleness with morphactin treatment is in correlation with the production of pistillate flowers in *Luffa acutangula* (2). Strong supression in maleness (21) and increase in maleness (10) is also reported. In the present study morphactin could not increase or decrease maleness significantly. A slight reduction in the height of the plant with morphactin treatment can be corrobarated with the results of inhibition of elongation growth of new growing internodes (14, 15).

Table 1.—Effect of kinetin and morphactin on changes in sex expression, node of flowering and height of the plant (Mean of ten replications).

	Control	Kinetin	Morphactin
Female flowers	32	57	45
Male flowers	152	92	148
Ratio of Female : Male	1:4.75	1:1.61	1:3.29
Node of flowering	17.8 ±0.88	19.0 ±1.08	19.3 ±1.18
Height of the plant in cm	98.5 ±1.98	113.8 ±3.11	93.1 ±1.31

	Female	Male flowers
F calculated	23.11*	31.14*
C.D. at 5% level	7.53	17.56

* Significant at P = 0.05.

Total and Inorganic phosphorus

A steep fall in total —P and inorganic— P content was noticed from stage 1 to 6, however, an increase was noticed at the fourth stage irrespective of the treatments. (Table 2). Kinetin and morphactin caused an increase in total-P and inorganic-P, more in the former than in the latter treatment. In the shoot tips, at the sixth stage the increase in total-P was 11.68% and 6.88% and inorganic-P was 30.59% and 20.14% with kinetin and morphactin treatments respectively. The percentage values are calculted from the

Table 2.—Changes in phosphorus fractions of shoot tips, female (Fe) and male (Ma) flowers of control, kinetin and morphactin treated plants (Mean of three replications)

mg/g dry weight

Stages	Control			Kinetin			Morphactin		
	To. P	In. P.	Or. P	To. P	In. P.	Or. P.	To. P.	In. P.	Or. P
1	6.91	5.49	1.42	—	—	—	—	—	—
S.E. ±	0.12	0.22							
2	5.66	3.75	1.91	—	—	—	—	—	—
S.E. ±	0.22	0.07							
3	4.77	2.62	2.15	—	—	—	—	—	—
S.E. ±	0.09	0.05							
4	5.34	2.64	2.76	5.77	2.95	2.82	5.64	2.84	2.80
S.E. ±	0.02	0.08		0.08	0.12		0.21	0.12	
5	4.28	1.72	2.56	5.09	2.47	2.62	4.56	1.98	2.58
S.E. ±	0.16	0.15		0.08	0.08		0.24	0.06	
6	4.17	1.34	2.83	4.66	1.75	2.91	4.46	1.61	2.85
S.E. ±	0.08	0.02		0.15	0.06		0.19	0.08	
Fe	3.42	1.53	1.89	3.84	1.68	2.16	3.73	1.59	2.14
S.E. ±	0.11	0.01		0.17	0.07		0.15	0.06	
7									
Ma	4.25	2.61	1.64	4.77	2.99	1.77	4.35	2.67	1.69
S.E. ±	0.13	0.12		0.02	0.12		0.22	0.10	

To. P: Total phosphorus; In. P: Inorganic phosphorus; Or. P: organic phosphorus

actual values although they are not included in the tables. Thus, more feminization was characterized by higher levels of total-P and inorganic-P. Total phosphorus content was high in shoot tips corresponding to high sugar content (19). Mac Gillivray (13) and Singh and Singh (23) illustrated that low phosphorus levels caused a relative increase in reducing sugars. The present study cannot corroborate their observation. Not all growth regulators cause an increase in PPi. Ormrod and Williams (17) found that 50 μg of 2,4-dichlorophenoxyacetic acid or gibberellic acid per plant applied as a spray caused decrease in PPi. Petioles and stems showed this effect. In the present study, activation of PPi accumulation by kinetin and morphactin occured in shoot tips indicating biosynthetic reactions operating at high rate in these parts.

Male flowers possessed higher amounts of total and inorganic-P than that of the female flowers. Kubarev (11) observed more inorganic-P in the ears than in panicles. This is contradictory to the observations in the present study.

Organic phosphorus

Lipid-P and nucleic acid-P increased from stage 1 to 6, except a slight decrease at stage 5; protein-P decreased from stage 1 to 3 then increased up to the last stage (Table 3). Both the treatments showed the same trend. At the sixth stage the increase in nucleic acid-P was 19.85% and 9.04%; protein-P was 11.42% and 7.14%; and the decrease in lipid-P was 20.77% and 21.67% with kinetin and morphactin treatments respectively. The results revealed that lipid and nucleic acid-P contents increased during vegetative and reproductive stages, whereas protein-P decreased during vegetative and increased during reproductive phases indicating that these are required for flower initiation. More feminization was characterised by high levels of nucleic acid-P and protein-P and low level of lipid-P.

Lipid, nucleic acid and protein phosphorus contents in female flowers surpass male ones, except the protein-P in the female flowers of control plants where it was lower than male flowers. Female and male

Table 3.—Changes in phosphorus fractions of shoot tips, female (Fe) and male (Ma) flowers of control, kinetin and morphacting treated plants. (Mean of three replications).

mg/g dry weight

Stages	Control			Kinetin			Morphactin		
	Li. P.	Nu. P	Pr. P.	Li P.	Nu P.	Pr. P.	Li. P.	Nu P.	Pr. P
1	0.45	0.44	0.52	—	—	—	—	—	—
S E. ±	0 03	0 01	0 02						
2	0.61	0.93	0.35	—	—	—	—	—	—
S E. ±	0 03	0 09	0 01						
3	0.71	1.18	0.26	—	—	—	—	—	—
S E. ±	0 01	0 12	0 01						
4	1 12	1 33	0 31	0 98	1.50	0.33	1.05	1 44	0 32
S.E. ±	0.04	0 05	0 01	0.04	0 08	0 01	0.04	0 01	0 01
5	0.96	1.28	0 33	0.82	1.44	0.36	0 90	1.34	0 35
S.E. ±	0 03	0.04	0 02	0 01	0 06	0 01	0.02	0 05	0 02
6	1 12	1.36	0.35	0.89	1 63	0.39	0 99	1 48	0 38
S E. ±	0 03	0 05	0 01	0 03	0.03	0.01	0 02	0 06	0 01
Fe	0 81	0 85	0.23	0.74	0.96	0.49	0.76	1 11	0 27
S E. ±	0 03	0 02	0.01	0.03	0.03	0 02	0 03	0 02	0.01
7									
Ma	0.71	0 62	0 31	0 67	0 81	0 29	0.68	0.79	0.22
S.E. ±	0 03	0 01	0.01	0.01	0 02	0.01	0.02	0 02	0.01

Li. P: Lipid phosphorus; Nu P: Nucleic acid phosphorus; Pr P: Protein phosphorus.

flowers of treated plants contained lower amounts of lipid, higher quantities of nucleic acid and protein-P than the flowers of control plants.

Calcium, potassium and sodium

Calcium content of the shoot tips decreased from stage 1 to 3 then increased up to the sixth stage, even with the treatments (Table 4). Calcium content was more in the male flowers than female flowers. Studies of Kwack (12) revealed that Ca binding takes place in the pectins of the pollen tube walls. Radioactive Ca incorporation was observed exclusively in the pollen tube wall regions of *Crinum asiaticum*. His studies probably indicate that male flowers require more Ca, and hence they contain more Ca. In the present study, Ca content was found to be more in the male flowers indicating that monoecius plants do not differ in the composition of minerals with respect to Ca durig sex differentiation.

Potassium content decreased during vegetative phase and increased during reproductive phase. Both the treatments increased potassium at all stages. At stage 6, the increase in potassium content was 60.29% with kinetin and 26.24% with morphactin treatment. The data indicate that more feminization was characterized by high levels of K in shoots tips. Male flowers were richer in K content than female flowers. Wakhloo (24) studied the effect of different levels of potassium in *Solanum sisymbrifolium* and concluded that plants having a higher K do not bear the female sterile flowers As K content was high in shoot tips of castor, female flowers that are fertile are produced, although their number is less than that of male flowers. Presence of high potassium in male flowers appears to be contradictory and in monoecious plants mineral composition of sexes may be different. The observation made by Dobrunov (6) that female organs have more mineral elements is not entirely correct in view of the present study as male flowers were characterized by higher potassium and calcium contents.

The content of sodium increased during the vegetative phase and decreased during the reproductive phase irrespective of the treatments. The increase in sodium content was 50.00 per cent with kinetin and

Table 4—Effect of kinetin an dmorphactin on changes in calcium, potassium and sodium contents of shoot tips, female (Fe) and male (Ma) flowers (Mean of three replications).

mg/g dry weight

Stages	Control			Kinetin			Morphactin		
	Ca	K	Na	Ca	K	Na	Ca	K	Na
1	2.80	15.52	0.78	—	—	—	—	—	—
S.E. ±	0.07	0.14	0.01						
2	2.08	10.96	0.82	—	—	—	—	—	—
S.E. ±	0.09	0.33	0.02						
3	1.84	11.76	1.02	—	—	—	—	—	—
S.E. ±	0.03	0.10	0.03						
4	1.68	10.56	1.14	2.00	13.52	1.26	2.32	11.76	1.18
S.E. ±	0.02	0.09	0.06	0.04	0.44	0.07	0.04	0.17	0.01
5	1.92	7.24	0.92	2.14	12.12	1.20	2.30	10.08	0.96
S.E. ±	0.07	0.08	0.03	0.08	0.36	0.07	0.05	0.31	0.03
6	1.98	8.46	0.74	2.18	13.62	1.02	2.44	10.68	0.80
S.E. ±	0.08	0.05	0.01	0.07	0.63	0.01	0.07	0.36	0.03
Fe	1.36	2.64	0.32	1.52	3.22	0.48	1.42	2.96	0.38
S.E. ±	0.01	0.07	0.02	0.14	0.07	0.01	0.04	0.05	0.01
7									
Ma	2.08	4.00	0.22	1.92	3.68	0.24	2.16	4.64	0.18
S.E. ±	0.05	0.13	0.01	0.07	0.05	0.01	0.07	0.17	0.01

18.75 per cent with morphactin treatment at the reproductive stage. More feminization was characterized by high level of sodium. Female flowers possessed higher sodium content than male ones.

Thus, in a final assessment of the results, it is concluded that morphactin exactly resembled kinetin in its response, although the effectiveness of the response is slightly less. It would be premature to draw any general conclusion as to how morphactin can simulate cytokinin although they are structurally different.

Summary

The effect of kinetin and morphactin on flower sex expression has been studied in castor (*Ricinus communis* L. var 'Aruna'). It was observed that the ratio of female to male flowers was 1:4.75 in control, 1:1.61 in kinetin and 1:3.29 in morphactin treated plants. Although the number of female flowers increased in morphactin treated plants the sex ratio did not alter much as there was no decrease in male flowers. Compared to control, height of the stem decreased and number of nodes increased with morphactin treatment, whereas height and number of nodes increased with kinetin.

The modification of sex expression is discussed with respect to phosphorus fractions and some mineral elements. Total-P, inorganic-P, nucleic acid-P and protein-P were increased, whereas lipid-P decreased with kinetin and morphactin treatments, when compared to control. Sodium, potassium and calcium contents were enhanced by both the treatments. Male flowers were characterized by higher levels of total-P and inorganic-P, and female flowers by higher levels of organic-P, lipid-P and nucleic acid-P. Potassium and calcium contents were higher in the male flowers and sodium higher in the female flowers. Increased feminization was caused by kinetin and morphactin, more by the former than by the latter. Thus, morphaction exactly behaved as kinetin.

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Notas y Comentarios

Publicaciones

Critica Andina. El Instituto de Estudios Sociales Cusco (IESC) de Cusco, Perú, está publicando desde 1978 una revista, *Critica Andina*, cuyo objeto es publicar ensayos, investigaciones y documentos relativos básicamente al área andina, como una forma de esclarecer y debatir acerca de la realidad social de la región. El IESC está compuesto por un equipo multidisciplinario de científicos sociales que combinan actividades académicas con la investigación, y que desean impulsar la investigación de problemas sociales en la región sur andina del Perú. El primer número, de fecha marzo de 1978 tiene siete artículos sobre dinero e inflación en la economía campesina (de E. González de Olarte); de utilización de recursos productivos en una economía agraria dominada por el latifundio (de Bruno Kervyn); el problema mercantil simple y la economía campesina de Espinar (de Marco Villasonte) y otros dos temas.

No se indica la periodicidad de la revista. El Director es Marco Villasonte y la dirección postal es: Director de Publicaciones, IESC, Casilla Postal 790, Cusco, Perú.

Avicultura Andina. Presentada como la única publicación de su tipo en Colombia, apareció en setiembre de 1977, la revista *Avicultura Andina*, destinada a servir a la industria avícola de Colombia, con proyecciones futuras a los países del Grupo Andino de América del Sur. Los dos primeros números estuvieron dedicados al Quinto Congreso Latinoamericano de Avicultura, celebrado en Bogotá en setiembre de 1977.

Aparace cada dos meses y el último que hemos recibido es el correspondiente el volumen 2, número 6, noviembre 1978.

El director actual es Mariano Trujillo García, y la dirección editorial es Av. 34 N° 20-50, Bogotá, D.E. Colombia.