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Effect of Paclobutrazol and Other Chemicals on Yield and Flowering Characteristics of Mango cv. Banganpalli

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ABSTRACT

The experiment was conducted in an orchard with 11-year old plants in the first evaluation cycle. Mango Trees were subjected to different concentrations of paclobutrazol and other chemicals with factorial randomised block design. Among the different treatments use of Paclobutrazol and other chemicals was significantly better in getting more number of mango fruits per tree as compared to the control. The more panicle length (36.24 and 33.83) was noticed with control, more per cent hermaphrodite flowers (3.49% and 3.20%) and less days to full bloom (96 and 100.17) was noticed with the treatment P_3 (PBZ @ 4 ml m^{-2}) followed by P_2 (PBZ @ 3 ml m^{-2}). Maximum number of fruits set per each panicle (17.7 and 15.4) was observed with P_3S_1 (PBZ @ 4 ml m^{-2} + Spermidine @ 0.02 mM). More fruit number per plant (212.33 and 208.33), yield (88.53kg, 107.67kg) and maximum fruit weight (625.20g and 588.53g), were noticed with P_3S_3 (PBZ @ 4 ml m^{-2} + NAA@ 25ppm). Therefore the conclusion from these results is that Paclobutrazol and other chemicals are effective in inducing flowering as well as fruiting in Banganpalli mango.

Key words: *Paclobutrazole, Other chemical, Yield, Flower characters*

INTRODUCTION

Mango occupied a pre-eminent place amongst the fruit crops grown in India because of its great utility. Mango exhibits wide variations in flowering and fruiting due to its strong dependency on environment for flowering, particularly on cool winter temperatures and the age of the flowering shoots[1,2]. There are several reasons that can be attributed for low productivity, but among them, the major cause is the dominance of vegetative phase over the reproductive phase, especially under tropical conditions.

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The improvement in productivity in modern agriculture system is increasingly dependent on manipulation of the physiological activities of the crop by chemical means. Alternate bearing is one of the major problems in mango production all over the World. Attempts are being made to overcome this problem during the last decades. Though several remedial measures have been suggested, none of these was successful until the advent of the plant growth retardant Paclobutrazol. In commercial mango plantations, it is desirable to control the vegetative growth to get uniform and regular flowering. The concerted research work has been carried out on use of paclobutrazol to overcome the alternate bearing problem in mango from early eighties till date in almost all the mango growing countries of the World. paclobutrazol is one of the most important growth retardant which restricts vegetative growth and induce flowering in many fruit species including mango[3]. The first report about the use of PBZ on mango came from India in Dashaheri and Banganapalli[4]. Keeping these points in view, the present investigation was planned to study the effect of Paclobutrazol and other chemicals on yield and flowering characteristics of mango cv. Banganpalli.

MATERIAL AND METHODS

The investigation on the effect of Paclobutrazol and other chemicals on yield and flowering characteristics of mango cv. Banganpalli was carried out at on farm research trials of CRIDA, Hyderabad at Amarachinta village, Mahaboobnagar district of Andhra Pradesh during 2013-14 and 2014-15. It lies at 16° 22' 0" North latitude, 77° 47' 0" East longitude at an altitude of 311m from mean sea level. Rainfall 1053.2 mm and 658.9 mm rainfall was received during 2013-14 and 2014-15 out of which >93% is during South West monsoon. The minimum temperature was 17.29^{o}C and 16.3^{o}C and maximum temperature was 30.63 and 30.72 ^{o}C. The soil of the orchard selected is a red soils with a pH of 6.7 and electrical conductivity of 0.6 d S m^{-1}. It had 131.63 Kg, 16.7 Kg and 179.84 Kg per hectare of available nitrogen, phosphorus and potassium contents respectively. The orchard has a uniform topography.

Paclobutrazol concentration was calculated based on the diameter of the tree, and applied @ 2ml m$^{-1,}$ 3ml m^{-1} and 4ml m^{-1} of canopy diameter. The required paclobutrazol was dissolved in 10 litre of water and poured in the holes (10-15cm depth) which were made in the soil around the collar region of the tree on september 1st of 2013 and 2014. A foliar spray of KNO_3 was applied during last week of October 2013 and 2014. 10 litres of NAA @25 ppm (25mg NAA dissolved in 20 ml of ethanol, diluted it to1litre of water and make up to 1 liters) solution was sprayed on trees during fruiting stage for controlling fruit drop. 10 litres of spermidine @ 0.02mM (2.9 mg of spermidine dissolved in 1 litre of water to get 0.02 mM of spermidine) was prepared and sprayed on trees during full bloom stage. 10 litres of borax @ 0.6% solution was prepared and sprayed on trees during full bloom stage during 2013 and 2014.

The length of the panicle was recorded and expressed in centimetres. The panicle lengths of ten randomly selected (North, South, East and West directions) shoots were recorded and the mean was calculated.

The breadth of the panicle was recorded and expressed in centimetres. The panicle breadths of ten randomly selected (North, South, East and West directions) shoots were recorded and the mean was calculated.

The number of days taken from the date of paclobutrazol application to full bloom was recorded. Ten shoots were randomly tagged (from North, South, East and West directions) and the Days taken from the date of paclobutrazol application to full bloom was recorded. The mean number of days taken for Days taken from the date of paclobutrazol application to full bloom was computed.

The percentage of hermaphrodite flowers was calculated from the randomly selected ten panicles tree^{-1} using the following formula and expressed in percentage.
Percentage of hermaphrodite flower =

$$\frac{\text{Number of hermaphrodite flowers}}{\text{Total number of flowers}} \text{X100}$$

An average of 5 fruited panicles was considered for calculating the average number of fruits panicle^{-1} at the time of fruit set stage.

The total number of fruits harvested tree^{-1} was counted after harvest and expressed as number of fruits plant^{-1}

The total weight of fruits produced by a tree was recorded to obtain the fruit yield tree^{-1} and expressed in kilograms.

RESULTS AND DISCUSSION

Among different paclobutrazol concentrations significantly more panicle length was noticed with the control (P_4) (36.24, 33.83) followed by application of PBZ @ 2 ml m^{-2} canopy (P_1) (30.04, 27.73) in the years 2013-14 and 2014-15 respectively (Table 1). The lowest panicle length was found with the application of PBZ @ 4 ml m^{-2} canopy (P_3) (23.79, 21.36) in the years 2013-14 and 2014-15 respectively. Interaction between paclobutrazol concentrations and application of other chemicals was found significant. The more panicle length was found with P_4S_4 (37.60, 35.10) which was statistically at par with P_4S_1 (36.83, 34.47) in the year 2013-14, 2014-15 respectively. Significantly the less panicle length was noticed with the treatment P_3S_3 (22.17, 19.70) which was statistically at par with P_3S_2 (22.67, 20.17) during 2013-14, 2014-15 seasons respectively. These results can be attributed to a reason that the Paclobutrazol reduces the panicle length by blocking gibberellin synthesis path way. This is why because gibberellins are responsible for cell elongation and in their reduced synthesis the elongation process gets diminished. This result is similar to that of Dalziel and Lawrence[5], Quinlan and Richardson[6], Webester and Quinlan[7] and Voon *et al.*[8].

Among different paclobutrazol concentrations significantly more panicle breadth was noticed with the treatment P_3 (24.97, 22.34) followed by P_2 (23.11, 20.83) in the year 2013-14, 2014-15 respectively(Table 2). The lowest panicle breadth was found with the treatment P_4 (14.17, 11.81) in the year 2013-14, 2014-15 respectively.

Among different paclobutrazol concentrations significantly less days to full bloom was noticed with the treatment P_3 (96, 100.17) followed by P_2 (103.5, 107.42) in the year 2013-14, 2014-15 respectively (Table 3).. Significantly the more days to full bloom was recorded with the treatment P_4 (126.33, 130.5) in the year 2013-14, 2014-15 respectively. It means flowering occurred about 30 days earlier than those of the control plants, it may be due to PBZ, owing to its anti-gibberellin activity and intensify flowering by early reduction of endogenous gibberellins levels within the shoots by blocks the conversion of ent kaurene to ent kaurenol in the terpenoid pathway. One of the major roles of gibberellins is the stimulation of cell elongation. When gibberellins biosynthesis is inhibited, cell division occurs, but new cells do not elongate resulting on suppression of vegetative growth Dalziel and Lawrence[5], Quinlan and Richardson[6], Webester and Quinlan[7], Voon *et al.*[8]. Similar results were also reported in different important mango cultivars from Australia[10], Indonesia[8], Thailand[11] and India[4].

Among different paclobutrazol concentrations significantly more hermaphrodite flowers was noticed with the treatment P_3 (3.49, 3.20) followed by P_2 (3.26, 2.99) in the year 2013-14, 2014-15 respectively (Table 4). Significantly the lowest hermaphrodite flowers was recorded with the treatment P_4 (2.13, 1.98) in the year 2013-14, 2014-15 respectively. The development of complete (hermaphrodite) flowers probably needs more reserves from the tree than unisexual flowers due to the additional structures. Assuming there are 100,000 flowers and each flower consumes 10 micro gram of nitrogen, then each time a tree flowers, it loses one kilogram of nitrogen. The tree will, therefore, need to have adequate reserves for flower and subsequent fruit formation. The higher reserve in the shoots due to PBZ soil drenching increased the percentages of hermaphrodite flowers. These results are similar to the observations made by Vijayalakshmi and Srinivasan[9], Hoda *et al.*[12].

With respect to fruit set, Interaction between paclobutrazol concentrations and other chemicals was found significant (Table 5). The highest fruit set per panicle was found with P_3S_1 (17.7) (15.4) in the year 2013-14, 2014-15 respectively. Significantly the less fruit set per panicle was noticed with the treatment P_4S_1 (6.3) which was statistically at par with

P_4S_2 (7.3), P_4S_3 (6.7), P_4S_4 (8.3), P_2S_3 (8.3), P_1S_3 (6.7), P_1S_4 (8.3) during 2013-14, whereas during 2014-15 seasons the lowest fruit set per panicle was noticed with the treatment P_4S_1 (4.0). The increase in fruit retention may be ascribed to synergistic effect of exogenous application of spermidine and paclobutrazol and It may also increased effectiveness of polyamines at full bloom stages may be improved floral organ development, pollination, fertilization, and subsequent embryo and initial fruit development. Our experimental results support the earlier report of Singh and Singh[13] that time of PA application significantly affected the fruit set and retention in 'Dusehri' and 'Langra' mango.

Different paclobutrazol concentrations and fruit set improving chemicals exerted significant influence on fruit number per plant in the years 2013-14, 2014-15 (Table 6).. Among different paclobutrazol concentrations, significantly the highest fruit number per plant was noticed with the treatment P_3 (199.50, 196.25) followed by P_2 (177.50, 173.0) in the year 2013-14, 2014-15 respectively. Significantly the less fruit number per plant was found with the treatment P_4 (121.50, 117.17) in the year 2013-14, 2014-15 respectively. This findings agreed in the experiments of Medonca PBZ increased the productivity of 'Tommy Atkins'. Most other researchers also indicated that PBZ treated trees had a higher yield than non-treated trees. Interaction between paclobutrazol concentrations and other chemicals was found significant. The more fruit number per plant was found with P_3S_3, P_3S_2 (212.33) in 2013-14, whereas during 2014-15 seasons the more fruit number per plant was observed with the treatment P_3S_3 (209.33). Significantly the less fruit number per plant was noticed with the treatment P_4S_3 (120.0, 116.0) in the year 2013-14, 2014-15 respectively.

Among different paclobutrazol concentrations, significantly the highest yield per plant was noticed with the treatment P_3 (83.32, 87.89) in the year 2013-14, 2014-15 respectively (Table 7). Significantly the less yield per plant was found with the treatment P_4 (40.74, 39.28) in the year 2013-14, 2014-15 respectively.

With respect to interaction effect, the more yield per plant was found with P_3S_3 (88.53) which was statistically at par with P_1S_3 (83.74), P_2S_1 (86.71), P_2S_2 (82.31), P_2S_3 (83.57), P_3S_1 (81.54) and P_3S_2 (84.40) in 2013-14, whereas during 2014-15 season the more yield per plant was observed with the treatment P_3S_3 (107.67) followed by P_2S_3 (89.20), P_2S_1 (86.86). Significantly the less yield per plant was noticed with the treatment P_4S_4 (36.60, 35.70) in the year 2013-14, 2014-15 respectively. This may be due to paclobutrazol hasten photosynthetic activities where more assimilates were accumulated, thus mango fruit yields significantly increased Our results confirms with Kulkarni , Burondkar and Gunjate[14], Kurian and Iyer[15], Singh and Dhillon[16], Singh[17], Tandel and Patel[18] and Burondkar *et al*[19].

Table 1: Panicle length as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Panicle length (cm)									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	29.00	30.17	32.17	28.83	**30.04**	26.80	27.93	29.80	26.37	**27.73**
P_2	27.17	25.17	28.53	28.33	**27.30**	24.70	22.80	26.27	26.00	**24.94**
P_3	26.00	22.67	22.17	24.33	**23.79**	23.60	20.17	19.70	21.97	**21.36**
P_4	36.83	35.47	35.07	37.60	**36.24**	34.47	33.13	32.63	35.10	**33.83**
Mean	**29.75**	**28.37**	**29.48**	**29.78**	**29.34**	**27.39**	**26.01**	**27.10**	**27.36**	**26.97**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	0.268		0.779			0.265		0.770		
Factor – S	0.268		0.779			0.265		0.770		
P × S	0.537		1.558			0.530		1.539		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_4- Control;
S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 – NAA @ 25ppm**;** S_4- Control

Table 2: Panicle breadth as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Panicle Breadth (cm)									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	15	15.17	17	17.37	**16.13**	12.93	13	14.7	14.97	**13.9**
P_2	19.67	23.7	24.03	25.03	**23.11**	17.17	21.4	21.87	22.87	**20.83**
P_3	24.33	24.67	24.17	26	**24.79**	22	22.2	21.6	23.57	**22.34**
P_4	13	14.17	14.33	15.17	**14.17**	10.57	12.1	11.9	12.67	**11.81**
Mean	**18**	**19.43**	**19.88**	**20.89**	**19.55**	**15.67**	**17.18**	**17.52**	**18.52**	**17.22**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	0.430		1.249			0.430		1.247		
Factor - S	0.430		1.249			0.430		1.247		
Interaction (P × S)	0.861		NS			0.859		NS		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_4- Control;
S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 - NAA@ 25ppm**;** S_4- Control

Table 3: Days taken for full bloom as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Days taken for full bloom									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	103.33	106.33	106.00	104.33	**105**	106.33	110.33	109.33	108.67	**108.67**
P_2	104.67	104.33	103.33	101.67	**103.5**	110.00	107.33	107.33	105.00	**107.42**
P_3	100.00	94.00	95.33	94.67	**96**	104.33	99.33	98.33	98.67	**100.17**
P_4	125.00	126.67	125.67	128.00	**126.33**	128.33	131.00	131.00	131.67	**130.50**
Mean	**108.3**	**107.8**	**107.6**	**107.2**	**107.71**	**112.25**	**112.00**	**111.50**	**111.00**	**111.69**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	0.697		2.024			0.792		2.299		
Factor - S	0.697		NS			0.792		NS		
Interaction (P × S)	1.395		NS			1.584		NS		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_4- Control;
S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 - NAA@ 25 ppm**;** S_4- Control

Table 4: Hermaphrodite flowers (%) as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Hermaphrodite flowers (%)									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	3.03	2.88	2.85	2.9	**2.92**	2.92	2.72	2.63	2.68	**2.74**
P_2	3.4	3.25	3.36	3.02	**3.26**	3.08	3.03	3.05	2.80	**2.99**
P_3	3.52	3.6	3.63	3.23	**3.49**	3.30	3.28	3.27	2.97	**3.20**
P_4	2.08	2.1	2.17	2.18	**2.13**	1.98	1.98	1.95	2.02	**1.98**
Mean	**3.01**	**2.96**	**3.00**	**2.83**	**2.95**	**2.82**	**2.75**	**2.72**	**2.62**	**2.73**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	0.051		0.149			0.052		0.150		
Factor - S	0.051		NS			0.052		NS		
Interaction (P × S)	0.103		NS			0.103		NS		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_4- Control;
S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 - NAA@ 25ppm**;** S_4- Control

Table 5: Fruit set panicle^{-1} as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Fruit set panicle^{-1}									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	9.0	8.7	6.7	8.3	**8.2**	6.7	5.4	4.4	7.0	**5.9**
P_2	11.0	9.0	8.3	9.0	**9.3**	8.7	5.7	6.0	7.7	**7.0**
P_3	17.7	15.0	14.7	13.3	**15.2**	15.4	11.7	12.4	12.0	**12.9**
P_4	6.3	7.3	6.7	8.3	**7.2**	4.0	4.0	4.4	7.0	**4.9**
Mean	**11.0**	**10.0**	**9.1**	**9.8**	**9.98**	**8.7**	**6.7**	**6.8**	**8.5**	**7.68**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	0.373		1.083			0.373		1.083		
Factor - S	0.373		1.083			0.373		1.083		
P × S	0.747		2.167			0.747		2.167		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_4- Control;
S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 - NAA@ 25ppm**;** S_4- Control

Table 6: Fruit number plant^{-1} as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Fruit number plant^{-1}									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	155.33	148.33	186.67	166.67	**164.25**	152.33	144.33	183.67	163.67	**161.00**
P_2	171.33	177.00	191.67	170.00	**177.50**	166.33	171.00	187.67	167.00	**173.00**
P_3	185.33	212.33	212.33	188.00	**199.50**	182.33	208.33	209.33	185.00	**196.25**
P_4	122.00	122.00	120.00	122.00	**121.50**	117.00	116.67	116.00	119.00	**117.17**
Mean	**158.50**	**164.92**	**177.67**	**161.67**	**165.69**	**154.50**	**160.08**	**174.17**	**158.67**	**161.86**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	1.518		4.407			1.506		4.371		
Factor - S	1.518		4.407			1.506		4.371		
Interaction (P × S)	3.037		8.813			3.012		8.741		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_4- Control; S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 - NAA@ 25ppm**;** S_4- Control

Table 7: Yield plant^{-1} as influenced by paclobutrazol and other chemicals in Mango cv. Banganpalli

Treatment	Yield plant^{-1} (kg)									
	2013-14					2014-15				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
P_1	65.31	69.04	83.74	71.04	**72.28**	64.04	67.17	82.38	69.76	**70.84**
P_2	86.71	82.31	83.57	77.20	**82.45**	86.86	79.34	89.20	76.00	**82.85**
P_3	81.54	84.40	88.53	78.79	**83.32**	82.80	83.55	107.67	77.54	**87.89**
P_4	42.75	43.00	40.62	36.60	**40.74**	41.00	41.13	39.29	35.70	**39.28**
Mean	**69.08**	**69.69**	**74.12**	**65.91**	**69.70**	**68.68**	**67.80**	**79.63**	**64.75**	**70.22**
	S.Em.(±)		C.D. @ 5%			S.Em.(±)		C.D. @ 5%		
Factor- P	1.225		3.556			1.716		4.979		
Factor - S	1.225		3.556			1.716		4.979		
Interaction (P × S)	2.450		7.112			3.431		9.958		

P_1 - PBZ @ 2 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_2 - PBZ @ 3 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%)
P_3 - PBZ @ 4 ml m^{-2} canopy (soil drenching) + foliar spray of KNO_3 (3%
P_4- Control;
S_1 - Spermidine @ 0.02 mM; S_2 - Borax – 0.6% ; S_3 - NAA@ 25ppm**;** S_4- Control

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