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IMPACT OF DIFFERENT WEED MANAGEMENT STRATEGIES ON WEED DENSITY, WEED BIOMASS, WEED CONTROL EFFICIENCY, GROWTH AND YIELD OF TARO (*COLOCASIA ESCULENTA* VAR. ANTIQUORUM)

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ABSTRACT

Colocasia is one of the most important tuber crops grown in India. Cormels and corms can be compared favourably in nutrition form with potatoes and cereals, its leaves are highly nutritious with good amount of protein and vitamins. The field experiment was conducted during the years 2021 and 2022, under All India Co-ordinated Research Project on Tuber Crops at Regional Horticultural Research and Extension Center, Dharwad (Karnataka). The experiment was laid out in RCBD design with eight treatments with three replications. The result revealed that the Higher WCE of 75.20 % was achieved with weed control ground cover mat mulching and it was followed by 78.04 % with hand weeding at 30 DAP+ Post emergence herbicide at 60 and 90 DAP in their pooled mean. Weed control ground cover mat mulching at 60 and 120 DAP recorded taller plants of 38.79 and 78.47 cm respectively with more Number of green leaves of 4.53 and 11.12, number of tillers (4.41 and 9.20) and leaf area index of 0.27 and 0.62 respectively in their pooled mean and significantly higher corm yield, cormel yield and total yield (6.08, 17.83 and 23.90 t ha^{-1} respectively in their pooled mean) was recorded in treatment with weed control ground cover mat mulching. Higher gross and net returns (□ 597515 and □ 389145 respectively) were obtained with hand weeding thrice at 30, 60 and 90 DAP, which was closely followed by weed control ground cover mat mulching (□ 513774 and □313404 respectively). Significantly higher B:C ratio (2.85) was recorded by ground cover mat mulch.

***Keywords*:** Weed density, weed control efficiency, *Colocasia esculenta* and Weed management

Introduction

Colocasia (*Colocasia esculenta var. antiquorum*) is a stem tuber crop that belongs to the family Araceae. It is a most important tuber vegetable of the world and is known as "Great leaved Caladium" or "Elephant ear" in English, "Dasheen" in USA and "Cocoyam" in West Africa. Colocasia is believed to have originated in South East Asian countries including India (Chang, 1958) and Malaysia (Keleny, 1962). Colocasia is one of the few edible species in the genus colocasia and is the most widely cultivated species (Vinning, 2003). Cultivated colocasia is classified as *Colocasia esculenta*, but the species is considered to be polymorphic. There are two botanical varieties of taro (Purseglove, 1972) viz. *Colocasia esculenta* var. esculenta and *Colocasia esculenta* var. antiquorum. *Colocasia esculenta* var. esculenta is characterised by the procession of a large cylindrical central corm and very few cormels. It is referred agronomically as the dasheen type of colocasia. On the other hand, *Colocasia esculenta* var. antiquorum, has a small globular central corm, with several relatively large cormels arising from the corm. Plants are perennial but cultivated as annuals, lactiferous and very variable herb with 30-150 cm in height. Leaves are large or rather large, obliquely erect, long petiole, with varying colour and size. Petiole is sheathering at the base, uniformly light or dark green, green with dark streaks or violet, 40-150 cm long. It consists mainly of the leaves with long petiole which arises in a whorl from the apex of the underground corm. Corms are cylindrical with short internodes and few side tubers.

Colocasia cormels and corms can be compared favourably in nutrition form with potatoes and cereals, its leaves are highly nutritious with good amount of protein and vitamins. The tuber of colocasia is rich source of starch (up to 21% of total carbohydrates), protein (above 3%) and minerals i.e. 3.9% (Markam *et al*., 2018). In India, colocasia is chiefly grown for human consumption and is used as food after peeled, sliced, cooked and taken with condiments and adjuncts. Colocasia is mainly cultivated for the edible tubers but the leaves and its young stacks petioles are cooked and also used for making pakoras. In some countries colocasia is used for making fermented products. The pressure cooked taro corms after being passed through strainer are allowed to ferment giving an acidic product called "poi". Taro flour is used as baby food and also used for making chips. Colocasia (*Colocasia esculenta* L. Schott) is a traditional crop with a long history of cultivation in Asia and the Pacific region. It is widely used as a tuber vegetable in India, whereas it is very closely associated with culture in many of the South Pacific Islands. It ranks third after cassava and yam, in terms of total production, area and consumption (Chukwu and Nwosu, 2008). In global scenario, Africa ranks first in the area and production of colocasia followed by Asia and Oceania. Despite of the importance of this crop, its cultivation anywhere in India is generally a subsistent to semi-commercial crop. In India, the major colocasia growing states are Manipur, Assam, Nagaland, Orissa, Meghalaya, Gujarat, Maharashtra, Kerala, Andhra Pradesh, Tamil Nadu, West Bengal, Uttar Pradesh and Bihar.

Weeds are potentially major constraints in producing higher yield and quality produce in tuber crops as they compete with the roots for applied resources and sometimes weed roots penetrate into the underground storage organs of tuber crops and reduce the quality of produce (Suresh *et al.* 2019). Taro is susceptible to weed growth especially during initial growth phases due to the time gap between planting and sprouting, and slower canopy spread in first few months (Ravindran *et al*. 2010). Weed infestation at the early stage of crop development causes severe yield reduction upto 100% in wide-spaced plantings (Nedunchezhiyan *et al*. 2018). Weeds compete for all available resources both below (water, nutrients, space) and above ground (space, light) and thereby reduce the crop growth and yield. Weeds are alternative hosts to many pests and disease causing organisms. Weeding alone requires more than 30% of the total labour in this crop and it is approximately 150-200 man days/ha (Nedunchezhiyan *et al*., 2018). Manual weeding is expensive, tedious and time consuming where the labour is scarce or where farm size is large. Application of herbicides for weed control as pre or post-emergence can reduce dependency on manual weeding and reduce cost of production and Another alternative to control weeds in a sustainable agricultural system is using synthetic materials or plant residues/waste on the soil, also known as mulching (Marin Guirao *et al*., 2022). One of the materials intensively used as mulch is plastic film. Mulch film improves soil temperature and moisture, providing a suitable environment for enzymes produced by the microorganism community and improving soil productivity. The additional advantage of mulching is improved weed management by preventing weed seed germination and blocking emerging seedlings' growth. Also, mulching blocks photosynthetically active radiation while allowing the infrared transmission to maintain the soil warm (Akhtar *et al*., 2018; Monteiro and Santos, 2022; Zhang *et al*., 2022). The present study was undertaken at All India Coordinated Research Project on Tuber Crops, Dharwad to find out the most effective weed management strategies option in taro.

Materials and Methods

The present investigations on taro were undertaken at Regional Research and Extension Center Dharwad. North Transitional Zone (Zone-III) of Karnataka state. It is located between 15.47^0 North latitude and 74.97^0 East longitudes at an altitude of 615 m above the mean sea level. The soil of experimental site was lateritic red soil in nature. The experimental field was prepared to a fine tilth by deep ploughing and harrowing. The field was ploughed twice before one month of planting and farm yard manure was incorporated at the rate of @ 20 t ha^{-1} at land harrowing and mixed well. Eight treatment consisted T_1 (*Pre emergence herbicide (1 DAP) + **Post emergence herbicide at 45&90 DAP), T_2 (Pre emergence herbicide (1 DAP) + Hand weeding at 45 and 90 DAP), T_3 (Hand weeding at 30 DAP+ Post emergence herbicide at 60 and 90 DAP),T_4 (Sowing cow pea in interspaces and incorporation at 45 DAP + Post emergence herbicide at 90 DAP), T_5 (Mulching with weed control ground cover mat 120 gsm), T_6 (Straw mulching in interspaces), T_7 (Check- Complete weed free-hand weeding at 30, 60 and 90 DAP), T_8 (Control-un weeded plot) were arranged in randomized block design with three replications. The land was prepared by deep ploughing, harrowing and leveling and there after plots were prepared. The calculated quantities of fertilizers were applied to the each plot.

The source of nutrients were nitrogen (DAP, Urea), phosphorus (DAP), potash (MOP). Half of nitrogen and whole dose of phosphorus and potash were applied as basal dose before plating of tubers. While the remaining half dose of nitrogen was given in 2 equal split doses, at 45 and 65 days after planting. Healthy tuber selected and planted in the field with the spacing of 60 x 45 cm. Irrigation was given immediately after planting and gap filling was done at 15 days after planting, to maintain the plant population in each plot and light irrigation was given just after gap filling.

From each net plot five plants were marked randomly as the representative sample for recording Observations. Plant height, number of green leaves, number of tillers and leaf area index were recorded from the selected five plants at 2 and 4 MAP (months after planting). Weed data collected on parameters such as occurring weed species, weeds density and biomass, weed index (WI) and weed control efficiency (WCE). The weed index (WI) defined as "the reduction in yield due to the presence of weeds in comparison with no weed plot" was worked out for each plot with the formula suggested by Gill and Kumar (1996) and expressed in percentage.

$$WI = [(X-Y)/X] * 100$$

Where, X= Yield from weed free plot; Y= Yield from the treated plot.

The weed control efficiency (WCE) was calculated by the following formula suggested by Rathod *et al* (1993) and expressed in percentage. WCE= [(DMC-DMT)/DMC]*100 Where, DMC= dry matter of weed in control plot; DMT= dry matter of weed in treatment plot. Corm yield, gross returns, cost of cultivation, net returns and B:C ratio were calculated after the crop harvest.

*Pre emergence herbicide Quizalofop ethyl@ 75 g a.i. ha^{-1}

** Post emergence herbicide Glyphosate 41 SL @ 1000 g a.i ha^{-1}

Results and Discussion

Weed density, weed biomass and weed control efficiency

Lower weed density and biomass were recorded with weed control ground cover mat mulching at all the growth stages except 40 DAP, which reduced total weed biomass, owing to complete cover of the ground which did not allow weeds to germinate and emerge. It was at par with straw mulching in interspaces at 80 DAP and at Harvest. The total weeds biomass is directly related to weed control efficiency (WCE). The Higher WCE of 75.20 % was achieved with weed control ground cover mat mulching and it was followed by 78.04 % with hand weeding at 30 DAP+ Post emergence herbicide at 60 and 90 DAP in their pooled mean, because of their lower weed biomass at 40 DAP. While at 80 DAP and at Harvest Significantly Higher WCE of 74.92 and 81.01 per cent respectively was achieved with weed control ground cover mat mulching and it was followed by straw mulching in interspaces (67.38 and 80.68 per cent respectively) in their pooled mean. Significantly higher weed density (111.79, 173.16 and 278.39 m^{-2} at 40, 80 DAP and harvest stage respectively in their pooled mean) and biomass (14.34, 21.04 and 36.39 g m^{-2} at 40, 80 DAP and harvest stage respectively in their pooled mean) were recorded in weedy check. Weed index (WI) was ranged from 0.00 to 51.50. Maximum weed index was recorded in the weedy check and the effective weed control treatment with lower weed index was weed control ground cover mat mulching (16.06). Better WCE with weed control ground cover mat mulching in elephant foot yam was reported by George and Sindhu (2017), Nedunzhiyan *et al.* (2018); in cassava (Nedunzhiyan *et al.*, 2017) and Marin Guirao *et al.* (2022).

Growth and yield attributes

The plant height, number of green leaves, number of tillers and leaf area index were significantly influenced by different weed control treatments (Table 5 and 6). All the treatments resulted in significantly taller plants than weedy check. Lesser weed infestation (weed biomass) in the treatments reduced competition for water, nutrients and space. It was aptly indicated by high WCE in the treatments (Table 3). Weed control ground cover mat mulching at 60 and 120 DAP recorded taller plants (38.79 and 78.47 cm respectively in their pooled mean). The increase in plant height under ground cover mat mulching may be due to a lower weed cover in the plots, reducing resource competition between the crop and weeds, and conserving soil moisture (Hussain *et al.*, 2022). Number of green leaves (4.53 and 11.12 respectively in their pooled mean), number of tillers (4.41 and 9.20 respectively in their pooled mean) and leaf area index (0.27 and 0.62 respectively in their pooled mean) and significantly higher corm yield, cormel yield and total yield (6.08, 17.83 and 23.90 t ha^{-1} respectively in their pooled mean) was recorded in treatment with weed control ground cover mat mulching. Lower crop growth and yield attributes due to suppression of weeds led to lower yield in weedy check. This may be due to season long crop-weed competition in weedy check plots, which was indicated by lower WCE, as well as lower crop growth and yield attributes (Table 6). Treatments with weed control ground cover recorded higher yields, due to effective control of weeds and marked improvement in the crop growth and yield attributes led to higher corm yield in these treatments. Plastic mulching reduces the cover of most weed species. It is a common production practice in intensive vegetable production systems because it increases soil temperature, improves water management, decreases growth of different weed species, and improves the use of nutrients in tomato (Bond and Grundy, 2001; El-Beltagi *et al*., 2022). Similar results also obtained by Suresh Kumar *et al.* (2020) in elephant foot yam.

Economics

Maximum cost of cultivation was incurred in weed control ground cover mat mulching due to its higher price per unit area (□ 22/m^2). As the durability of soil covering ground cover mat is five years, if it is reused for more years can reduce expenditure on purchase of soil covering ground cover mat mulch. Higher gross and net returns (□ 597515 and □ 389145 respectively) were obtained with hand weeding thrice at 30, 60 and 90 DAP, which was closely followed by weed control ground cover mat mulching (□ 513774 and □313404 respectively). Significantly higher B:C ratio (2.85) was recorded by ground cover mat mulch and lower B:C ratio (1.84) in weedy check. The results conforms the findings of Suresh Kumar *et al*. (2019) in elephant foot yam.

Conclusion

It may be concluded that hand weeding is an effective and economical weed management option for managing weeds in taro. Weed control ground cover mat mulch may be advised as better alternative weed management options, where laborers are scarce and costly.

Table 1 : Weed Density at different growth stages of taro as influenced by different weed management strategies

Treatments	Weed density (1 m^2) 40 DAP			Weed density (1 m^2) 80 DAP			Weed density (1 m^2) 120 DAP		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	92.43	84.92	88.67	116.87	109.71	113.29	91.87	81.83	86.85
T_2	83.79	77.82	80.80	113.68	104.87	109.27	106.58	94.96	100.77
T_3	25.14	23.97	24.56	68.73	63.29	66.01	112.57	100.25	106.41
T_4	61.72	57.45	59.58	118.44	109.25	113.85	121.76	108.41	115.08
T_5	26.98	28.46	27.72	45.03	42.13	43.58	55.65	49.55	52.60
T_6	42.23	39.30	40.77	58.75	53.37	56.06	56.54	50.49	53.51
T_7	27.37	25.33	26.35	34.78	32.93	33.86	45.49	40.50	42.99
T_8	115.87	107.71	111.79	178.89	167.43	173.16	302.43	254.35	278.39
Mean	59.44	55.62	57.53	91.90	85.37	88.63	111.61	97.54	104.58
S.Em.±	2.94	3.39	3.07	4.74	5.17	4.94	5.82	7.49	6.63
C.D. at 5%	8.90	10.29	9.31	14.36	15.69	14.99	17.64	22.73	20.11
CV %	8.55	10.56	9.24	8.93	10.49	9.66	9.02	13.31	10.98

Table 2 : Weed Biomass at different growth stages of taro as influenced by different weed management strategies

Treatments	Dry matters (g/m^2) 40 DAP			Dry matters (g/m^2) 80 DAP			Dry matters (g/m^2) 120 DAP		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	11.70	11.16	11.43	13.60	13.23	13.41	11.12	11.00	11.06
T_2	10.61	10.14	10.37	13.57	13.21	13.39	12.90	12.76	12.83
T_3	3.18	3.04	3.11	8.18	7.97	8.08	13.63	13.47	13.55
T_4	7.81	7.47	7.64	14.15	13.77	13.96	14.74	14.57	14.65
T_5	3.42	3.27	3.34	5.36	5.22	5.29	6.74	6.66	6.70
T_6	5.35	5.11	5.23	7.02	6.83	6.93	6.85	6.77	6.81
T_7	3.46	3.31	3.39	4.15	4.04	4.10	5.51	5.44	5.48
T_8	14.67	14.02	14.34	21.31	20.76	21.04	36.59	36.18	36.39
Mean	7.52	7.19	7.36	10.92	10.63	10.77	13.51	13.36	13.43
S.Em.±	0.37	0.34	0.35	0.70	0.69	0.69	0.85	0.79	0.82
C.D. at 5%	1.13	1.03	1.07	2.13	2.10	2.11	2.58	2.40	2.48
CV %	8.55	8.21	8.29	11.14	11.29	11.17	10.90	10.24	10.54

Table 3 : Weed control efficiency at different growth stages of taro as influenced by different weed management strategies

Treatments	Weed control efficiency 40 DAP			Weed control efficiency 80 DAP			Weed control efficiency 120 DAP			Weed index		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	20.58	21.55	21.07	34.51	34.28	34.40	69.65	67.63	68.64	38.82	38.23	38.53
T_2	27.67	27.74	27.70	36.03	36.89	36.46	64.79	62.43	63.61	51.84	51.17	51.50
T_3	78.30	77.78	78.04	61.71	62.30	62.01	62.81	60.35	61.58	39.38	38.74	39.06
T_4	46.71	46.66	46.68	33.32	34.19	33.76	59.77	57.12	58.45	43.13	41.38	42.26
T_5	76.70	73.70	75.20	74.92	74.91	74.92	81.62	80.40	81.01	17.24	14.87	16.06
T_6	63.53	63.58	63.56	66.92	67.83	67.38	81.32	80.04	80.68	28.27	26.85	27.56
T_7	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00
T_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.14	53.67	48.40
Mean	51.69	51.38	51.53	50.93	51.30	51.11	64.99	63.50	64.25	32.73	33.11	32.92
S.Em.±	1.77	2.86	2.28	1.57	1.53	1.47	3.09	1.88	1.79	4.62	8.11	5.36
C.D. at 5%	5.37	8.68	6.92	4.77	4.65	4.47	9.38	5.69	5.43	14.01	24.59	16.26
CV %	5.93	9.64	7.67	5.35	5.17	5.16	8.24	5.12	6.12	18.56	21.56	22.56

Table 4 : Growth parameters at different growth stages of taro as influenced by different weed management strategies

Treatments	Plant height (cm) 60 DAP			Plant height (cm) 120 DAP			No. of green leaves 60 DAP			No. of green leaves 120 DAP		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	32.69	35.31	34.00	75.60	77.40	76.50	3.93	4.23	4.08	7.67	8.35	8.01
T_2	31.04	33.52	32.28	67.48	69.05	68.27	4.04	4.36	4.20	9.00	9.82	9.41
T_3	31.73	34.14	32.93	68.63	70.20	69.42	4.08	4.40	4.24	9.67	10.51	10.09
T_4	31.70	34.29	33.00	67.60	69.73	68.67	4.00	4.33	4.16	8.33	9.10	8.72
T_5	36.93	40.65	38.79	77.55	79.39	78.47	4.19	4.88	4.53	10.67	11.57	11.12
T_6	34.62	37.34	35.98	75.13	76.87	76.00	3.89	4.20	4.05	7.00	7.59	7.29
T_7	36.81	40.03	38.42	78.54	80.33	79.44	4.22	4.75	4.48	9.33	10.18	9.76
T_8	28.61	30.95	29.78	55.78	57.10	56.44	3.78	3.67	3.73	7.00	7.44	7.22
Mean	**33.02**	**35.78**	34.40	**70.79**	**72.51**	71.65	**4.02**	**4.35**	4.18	**8.58**	**9.32**	8.95
S.Em.±	1.78	2.44	2.09	4.74	5.01	4.86	0.26	0.38	0.31	0.69	0.78	0.73
C.D. at 5%	5.41	7.39	6.33	14.37	15.21	14.74	0.79	1.15	0.94	2.08	2.38	2.23
CV %	9.36	11.79	10.52	11.59	11.98	11.75	11.17	15.11	12.83	13.84	14.59	14.20

Table 5 : Growth parameters at different growth stages of taro as influenced by different weed management strategies

Treatments	No. of tillers 60 DAP			No. of tillers 120 DAP			LAI 60 DAP			LAI 120 DAP		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	3.67	4.25	3.96	7.12	8.18	7.65	0.18	0.20	0.19	0.39	0.41	0.40
T_2	3.89	4.48	4.18	8.50	9.68	9.09	0.16	0.18	0.17	0.35	0.37	0.36
T_3	3.89	4.50	4.19	8.31	9.52	8.92	0.20	0.21	0.21	0.37	0.39	0.38
T_4	3.11	3.62	3.36	6.50	8.16	7.33	0.17	0.18	0.17	0.32	0.35	0.33
T_5	3.89	4.93	4.41	8.59	9.81	9.20	0.26	0.28	0.27	0.60	0.63	0.62
T_6	3.66	4.23	3.95	6.70	7.64	7.17	0.19	0.20	0.19	0.40	0.42	0.41
T_7	3.44	4.24	3.84	8.38	9.54	8.96	0.28	0.30	0.29	0.52	0.56	0.54
T_8	3.07	3.55	3.31	6.56	7.19	6.88	0.12	0.14	0.13	0.24	0.26	0.25
Mean	**3.58**	**4.22**	3.90	**7.58**	**8.71**	8.15	**0.20**	**0.21**	0.20	**0.40**	**0.42**	0.41
S.Em.±	0.17	0.26	0.20	0.36	0.53	0.40	0.017	0.02	0.02	0.03	0.03	0.03
C.D. at 5%	0.52	0.77	0.60	1.09	1.61	1.22	0.05	0.06	0.05	0.09	0.09	0.09
CV %	8.37	10.46	8.85	8.21	10.58	8.58	15.51	15.60	15.47	12.59	12.25	12.41

Table 6 : Yield of taro as influenced by different weed management strategies

Treatments	Corm yield per ha(t)			Cormel yield per ha(t)			Total yield per ha (t)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	3.52	4.67	4.09	11.36	14.92	13.14	14.88	19.59	17.24
T_2	3.28	4.36	3.82	10.32	13.56	11.94	13.61	17.91	15.76
T_3	3.66	4.86	4.26	11.16	14.65	12.91	14.82	19.51	17.17
T_4	3.72	4.93	4.33	10.71	14.07	12.39	14.43	19.00	16.72
T_5	5.22	6.93	6.08	15.43	20.22	17.83	20.66	27.14	23.90
T_6	4.57	6.10	5.34	11.67	15.28	13.47	16.24	21.38	18.81
T_7	4.60	6.13	5.37	13.10	17.27	15.19	17.70	23.40	20.55
T_8	3.11	2.46	2.79	8.60	9.42	9.01	11.72	11.88	11.80
Mean	**3.96**	**5.06**	**4.51**	**11.55**	**14.92**	**13.23**	**15.51**	**19.98**	**17.74**
S.Em.±	0.18	0.31	0.24	0.78	0.90	0.88	0.99	1.54	1.22
C.D. at 5%	0.54	0.94	0.73	2.35	2.72	2.65	2.98	4.66	3.66
CV %	7.81	10.56	9.25	7.95	10.42	8.23	6.57	13.32	8.55

Table 7 : Economics of taro cultivation as influenced by different weed management

Treatments	Total Yield per ha (t)	Cost of cultivation (≠)	Gross returns (≠)	Net returns (≠)	B:C ratio
T_1	17.24	167750	430911.25	263161.25	2.57
T_2	15.76	207510	393962.92	186452.92	1.9
T_3	17.17	187810	429202.5	241392.5	2.29
T_4	16.72	184270	417963.75	233693.75	2.27
T_5	20.55	189505	513774.58	313404.58	2.71
T_6	18.81	195370	470288.33	274918.33	2.41
T_7	23.9	209780	597515	389145	2.85
T_8	11.8	160370	294958.33	134588.33	1.84

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