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Effect of intercropping and weed management practices on growth and yield of cabbage (*Brassica oleracea* var. *capitata*)

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Abstract
The present investigation was carried out at Vegetable Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar during the year 2018-19 and 2019-20 in *Rabi* season involving twenty-eight treatments consisting of seven different intercropping systems *viz*: T_1 - Cabbage (Sole), T_2 - Cabbage + Coriander, T_3 - Cabbage + Nigella, T_4 - Cabbage + Fenugreek, T_5 - Coriander (Sole), T_6 - Nigella (Sole), T_7 - Fenugreek (Sole) and four weed management practices *viz:* W_0 - Control (Weedy check), W_1 - (Hand weeding), W_2 - (Pendimethalin PE @ 3.3 l/ha) and W_3 - (Pendimethalin PE @ 3.3 l/ha + one hand weeding at 30 DAS) in split plot design replicated thrice. Pooled results indicated that the intercropping, cabbage + nigella recorded maximum plant height (23.08 cm), number of unwrapped leaves (10.96), gross weight (1.38 kg/plant), head weight (1.06 kg/plant), yield (24.33 kg/plot) yield (270.21 q/ha) and head compactness (47.77 g/cm^3), which was significantly superior to the rest of intercrops (Fenugreek and coriander) except cabbage (Sole). Similarly, among the various weed management practices, W_3 (Pendimethalin PE @ 3.3 l/ha + one hand weeding at 30 DAS) recorded maximum plant height (24.60 cm), number of unwrapped leaves (11.61), gross weight (1.49 kg), head weight (1.28 kg/plant), yield per plot (29.35 kg) yield per hectare (325.90 q) and head compactness (38.83 g/cm^3), which was significantly superior to the rest of weeding methods except W_1 (Hand Weeding) treatment at 15, 30 and 45 DAS.

Keywords: Cabbage, intercropping, pendimethalin, head compactness, yield

Introduction
Cabbage is the most important crop under Cole group belonging to family Crucifereae. It is rich in Vit C, β-carotene, fiber and phytonutrients especially compounds that protect against cancer. It contains glucosinolates which serve as metabolic detoxicants or due to the sulphoraphane content, responsible for metabolic anti-carcinogenic activities. The particular flavor in the cabbage head is due to the glycoside "sinigrin" which also contains sulphur. Cabbage and cabbage products are interesting from both marketing and dietary points of view because cabbage has many beneficial effects on health. From a traditional point of view, cabbage in the form of sauerkraut is one of the best known traditional foods (Jevšnik *et al*., 2009) [10]. In India, cabbage is cultivated in an area of about 0.39 m ha with the annual production of 9.213 m t (3rd Advance Estimate, NHB - 2019-20) [2] and the major cabbage producing states are Uttar Pradesh, Bihar, Odisha, West Bengal, Assam, Maharashtra and Karnataka.

Cabbage is widely spaced crop and more responsive to fertilizer and irrigations for proper growth and higher yield, which poses a serious problem of weeds. Reduction in economic yield of vegetables has been reported to be 45–80 per cent in cabbage (Akshatha *et al*., 2018) [1], 6- 82 per cent in potato, 25-30 per cent in peas, 70-80 per cent in carrot, 67 per cent in onion, 42- 71 per cent in tomato and 61 per cent in cauliflower. Farmers usually have a various methods for weed control and their choice of control measures is closely controlled by economics (Singh *et al*, 2019) [18]. Weeds compete with the crops for water, soil; nutrients, light and space thus reduce crop yields up to 37 per cent (Varshney, 2007) [19]. The excessive use of toxic substances as plant protection measures threatened productivity, profitability, stability and durability of the system, which emphasizes the need based application of all inputs. On the other hand manual weeding involves high cost for laborers, which makes imperative to opt herbicidal control of weeds. Pre-emergence herbicides provide early season weed control when competition results in the greatest yield reduction and when other methods

are less efficient and also reduces the destruction of soil structure by decreasing the need for tillage. Under the situation referred above the concept of inter cropping offers ample scope for combating weeds without any threat to ecological degradation. It enhances the economic condition of farmers by increasing the cropping intensity. Intercropping under fragile environmental conditions ensures stability in yield and minimizes risk of crop loss due to weather aberrations (Sharma *et al*., 2006) [17]. Considering above views the present investigation was undertaken to explore the possibilities of weed management practices and intercropping on growth and yield of cabbage.

Materials and Methods

The present investigation was carried out during the year 2018-19 and 2019-20 in *Rabi* season at Vegetable Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. The geographical location of Bhagalpur comes under the Middle Gangetic plain region of Agro-climatic Zone III-A. It is situated between 25°50' N latitude and 87°19' E longitude at an altitude of 39 meters above mean sea-level. Twenty-eight treatment combinations consisting of seven different intercropping systems *viz:* T_1 - Cabbage (Sole), T_2 - Cabbage + Coriander, T_3 - Cabbage + Nigella, T_4 - Cabbage + Fenugreek, T_5 - Coriander (Sole), T_6 - Nigella (Sole), T_7 - Fenugreek (Sole) and four weed management practices *viz*: W_0 - Control (Weedy check), W_1 - (Hand weeding), W_2 - (Pendimethalin PE @ 3.3 l/ha) and W_3 - (Pendimethalin PE @ 3.3 l/ha + one hand weeding at 30 DAS) were laid out in split plot design with three replications. The sowing of cabbage was done in *Rabi season* respectively, during the years, using the variety Golden Acre at spacing of 50 cm plant to plant and 45 cm row to row distance. The sowing of seed spices like Coriander (Pant Haritma), Black cumin (Rajendra Shyama) and Fenugreek (Rajendra Kranti) was also done the same day at a spacing of 30 x 10 cm as intercrop. The recommended dose of nitrogen, phosphorus and potassium for cabbage (120:80:80 kg/ha) and for seed spices (20:60:40 kg/ha) was applied for better growth and development of crops. Application of Pendimethalin PE @ 3.3 l/ha as per treatment was done as pre emergence for the management of weeds.

Results and Discussion

Effect of intercropping

Pooled analysis of data presented in Table 1 indicated that Intercropping system had significant effect on growth attributing characters *viz.*, plant height and number of unwrapped leaves of cabbage (sole) and recorded maximum value of 24.91 cm and 12.11, respectively however, these showed decreasing trend when intercropped with nigella, fenugreek or coriander. Cabbage + nigella intercropping system recorded comparatively lower values of the growth parameters than cabbage (Sole) and higher values (23.08 cm and 10.96) of both the parameters than other intercrops in intercropping system. The higher values of said parameters in sole crop as well as in cabbage + nigella intercropping was mainly due to comparatively lesser competition for light, nutrients, moisture and space than other intercropping situations. Besides, intercropping system played a significant role in suppressing of weeds by promoting quick growth and better canopy coverage that created hindrance in the proper growth and development of weeds in intercropping systems by inhibiting the interception of solar radiation and promoted. The growth of cabbage under cabbage + nigella cropping system by way of reducing the weed count as well as dry matter accumulation by weeds. The similar findings have also been made by Kumar *et al.*, 2003 [11]; Pandey *et al.*, 2003 [15] and Dhima *et al.*, 2007) [6].

Intercropping system had significant effect on yield attributing characters *viz.*, head weight per plant, gross weight of per plant, yield per plot and yield per hectare of cabbage (Table 2, 3 and 4) and recorded maximum values under sole treatment of cabbage (1.14 kg/plant, 26.31 kg/plot and 292.13 q/ha) followed by cabbage + nigella (1.06 kg/plant, 24.33 kg/plot and 270.21 q/ha) intercropping system as compared to other intercrops. However, decreasing trend on above parameters was noticed with either nigella, fenugreek or coriander intercrops. The progressive increase in the parameters under cabbage (sole) may only be due to the fact that sole crop might have utilised the maximum resources due to lesser competition for light, nutrients, moisture and space than the intercrops. Likewise, among the intercrops, cabbage + nigella performed better than all other intercrops and boosted up all the yield and yield attributing traits. It is well known fact that for the success of any intercropping system from biological point of view, proper choice of crops is a pre-requisite so as to make best use of space and time with minimum competition. The taller component should be tolerant to high solar radiation while the shorter component is shade tolerant. Peak demand for light nutrient, moisture and space for component crops should not coincide. Similarly, rooting pattern should be of different nature so as to exploit different soil layers for nutrient and moisture by different crop combinations (Haque, 2006) [9]. Head yield is a complex phenomenon resulting from the interaction of plant with the environment and management. The main physiological basis for greater stability of head yield in intercropping is that if one crop fails to grow poorly, another component crop can compensate but such compensation cannot occur if crops are grown separately. It is paramount important that, competition from weeds must be minimized to achieve optimum yield. The similar findings are in close conformity with Kumar *et al.*, 2003 [11]; Pandey *et al.*, 2003 [15]; Bhutia *et al.*, 2005 [4]; Dhiman *et al.*, 2005 [7]; Dhima *et al.*, 2007) [11, 15, 4, 7, 6].

Pooled data regarding head compactness (Table 3) showed that the cabbage + nigella recorded minimum head compactness (47.77 g/cm^3), which was significantly lower than entire inter crops with cabbage except cabbage (Sole), however maximum head compactness (54.20 g/cm^3) was recorded under cabbage + coriander treatment. Minimum value indicates the more compactness of curd, while maximum value indicates the loose head of cabbage. Minimum value of compactness in sole crop may be due to the fact that sole crop might have received all the favorable environment like solar radiation, nutrients, moisture, space, etc to convert solar energy to biological yield. Higher photsynthates might have utilized in increasing the number of wrapped leaf to make it more compact. More compactness also might be due to the fact that less diameter compared to more diameter of head under the treatment (Chaudhary *et al.*, 2018) [5].

Effect of weed management practices

Weed management practices had significant effect on growth and yield attributing characters *viz*., plant height, number of unwrapped leaves, head weight per plant, gross weight of per plant, yield per plot and per hectare of cabbage (Table 1,2,3

and 4) and recorded maximum values (24.60 cm, 11.61, 1.28 kg/plant, 1.49 kg/plant, 29.35 kg/plot and 325.90 q/ha, respectively) under W_3 (Pendimethalin PE @ 3.3 l/ha + hand weeding at 30 DAS) treatment except W_1 (Hand Weeding) treatment and minimum values observed under weedy check (W_0) treatment. The reduction in weed population was in the order of hand weeding (W_1) > Pendimethalin PE @ 3.3 l/ha + hand weeding at 30 DAS (W_3) > Pendimethalin PE @ 3.3 l/ha (W_2) > and weedy check (W_0). This order of reduction in weed population was mainly due to increasing in weed control efficiency and decreasing the weed population and competition between crop and weeds for nutrients, solar radiation, space and moisture. The present findings are in close conformity with the findings of Eskandari and Ghanbari 2010 [8]; Bharathi *et al.*, 2011 [3]; Kathepuri *et al.*, 2011 [12]; Kumar *et al.*, 2012 [13]; Orluchukwu *et al.*, 2013 [14]; Patil *et al.*, 2020) [16].

Table 1: Plant height and number of unwrapped leaves per plant of cabbage as influenced by intercropping of cabbage with different spices and weed management practices

Treatment	Plant height (cm)			No of unwrapped leaves		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Intercropping						
Cabbage (Sole)	24.02	25.80	24.91	11.45	12.77	12.11
Cabbage + Coriander	18.92	20.53	19.72	8.25	10.00	9.13
Cabbage + Nigella	22.48	23.68	23.08	10.05	11.88	10.96
Cabbage + Fenugreek	21.02	21.88	21.45	9.19	11.05	10.12
SEm±	0.159	0.100	0.129	0.084	0.091	0.088
CD (P = 0.05)	0.39	0.24	0.31	0.20	0.22	0.21
Weeding						
W_0 (Weedy check)	15.60	17.70	16.65	6.49	8.69	7.59
W_1 (Hand Weeding)	26.00	27.28	26.64	12.76	13.43	13.10
W_2 (Pendimethalin)	20.78	21.77	21.28	9.11	10.93	10.02
W_3 (Pendimethelin + HW)	24.05	25.15	24.60	10.58	12.65	11.61
SEm±	0.152	0.082	0.117	0.081	0.063	0.072
CD (P = 0.05)	0.31	0.17	0.24	0.17	0.13	0.15

W_2 (Pendimethalin PE @ 3.3 l/ha), W_3 (Pendimethalin PE @ 3.3 l/ha + hand weeding at 30 DAS)

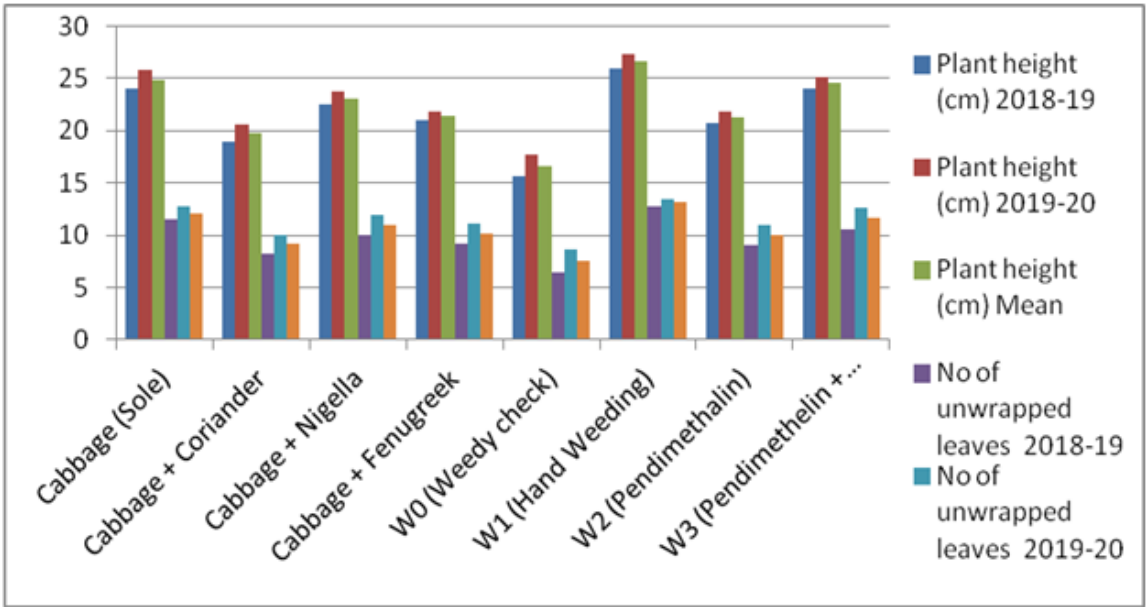

Fig 1: Shows in plant height (cm) 2018-19, no of unwrapped leaves 2018-19

Table 2: Head weight per plant and yield per plot of cabbage as influenced by intercropping of cabbage with different spices and weed management practices

Treatment	Head weight (kg/ plant)			Yield (kg/ plot)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Intercropping						
Cabbage (Sole)	1.12	1.17	1.14	25.65	26.97	26.31
Cabbage + Coriander	0.89	0.91	0.90	20.47	20.97	20.72
Cabbage + Nigella	1.04	1.08	1.06	23.81	24.86	24.33
Cabbage + Fenugreek	0.98	1.00	0.99	22.54	22.98	22.76
SEm±	0.002	0.005	0.005	0.048	0.123	0.085
CD (P = 0.05)	0.01	0.01	0.01	0.14	0.36	0.25
Weeding						
W_0 (Weedy check)	0.62	0.63	0.62	14.15	14.41	14.28

W_1 (Hand Weeding)	1.38	1.42	1.40	31.63	32.55	32.09
W_2 (Pendimethelin)	0.77	0.83	0.80	17.71	19.11	18.41
W_3 (Pendimethelin + HW)	1.26	1.29	1.28	28.98	29.71	29.35
S.Em±	0.016	0.015	0.012	0.370	0.358	0.364
CD (P = 0.05)	0.05	0.05	0.03	1.31	1.26	1.29

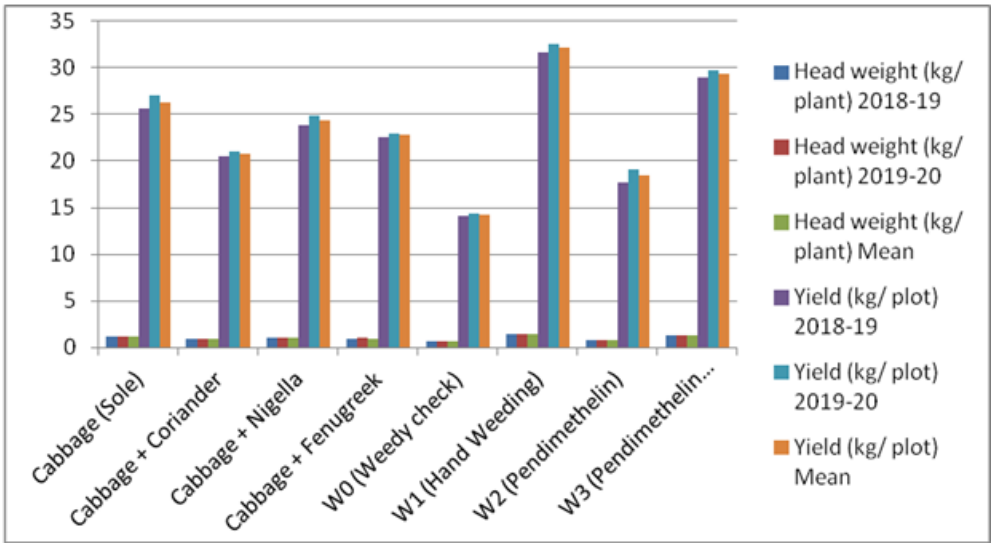

Fig 2: Shows in Head weight (kg/plant) 2018-19 Yield (kg/plot) 2018-19

Table 3: Head compactness and gross weight of plant of cabbage as influenced by intercropping of cabbage with different spices and weed management practices

Treatment	Head compactness (g/ cm^3)			Gross weight (kg/ plant)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Intercropping						
Cabbage (Sole)	44.19	44.77	44.48	1.45	1.60	1.53
Cabbage + Coriander	53.58	54.82	54.20	1.09	1.19	1.14
Cabbage + Nigella	47.83	47.71	47.77	1.28	1.47	1.38
Cabbage + Fenugreek	50.47	50.28	50.37	1.20	1.36	1.28
SEm±	0.330	1.233	0.781	0.006	0.016	0.014
CD (P = 0.05)	0.97	3.62	2.30	0.01	0.05	0.03
Weeding						
W_0 (Weedy check)	70.09	69.13	69.61	0.89	0.98	0.94
W_1 (Hand Weeding)	36.70	34.67	35.68	1.57	1.82	1.70
W_2 (Pendimethelin)	50.78	54.62	52.70	1.18	1.22	1.20
W_3 (Pendimethelin + HW)	38.50	39.16	38.83	1.38	1.60	1.49
S.Em±	2.458	2.143	2.301	0.010	0.011	0.013
CD (P = 0.05)	8.67	7.56	8.12	0.03	0.03	0.02

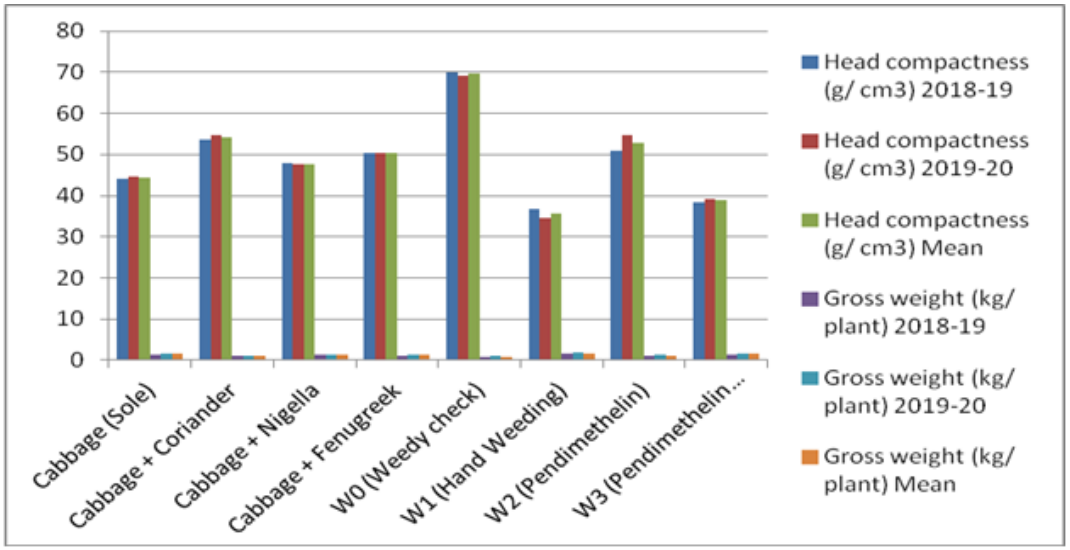

Fig 3: Shows in head compactness (g/cm^3) mean, Gross weight (kg/plant) 2019-20

Table 4: Yield quintal per hectare of cabbage as influenced by intercropping of cabbage with different spices and weed management practices

Treatment	Yield (q/ ha)		
	2018-19	2019-20	Mean
Intercropping			
Cabbage (Sole)	284.92	299.34	292.13
Cabbage + Coriander	227.42	232.80	230.11
Cabbage + Nigella	264.47	275.94	270.21
Cabbage + Fenugreek	250.42	255.09	252.76
SEm±	0.535	1.363	1.444
CD (P = 0.05)	1.57	4.00	3.53
Weeding			
W_0(Weedy check)	157.15	159.99	158.57
W_1 (Hand Weeding)	351.35	361.25	356.30
W_2 (Pendimethelin)	196.76	212.11	204.44
W_3 (Pendimethelin + HW)	321.97	329.82	325.90
S.Em±	4.11	3.972	3.123
CD (P = 0.05)	14.51	14.01	6.45

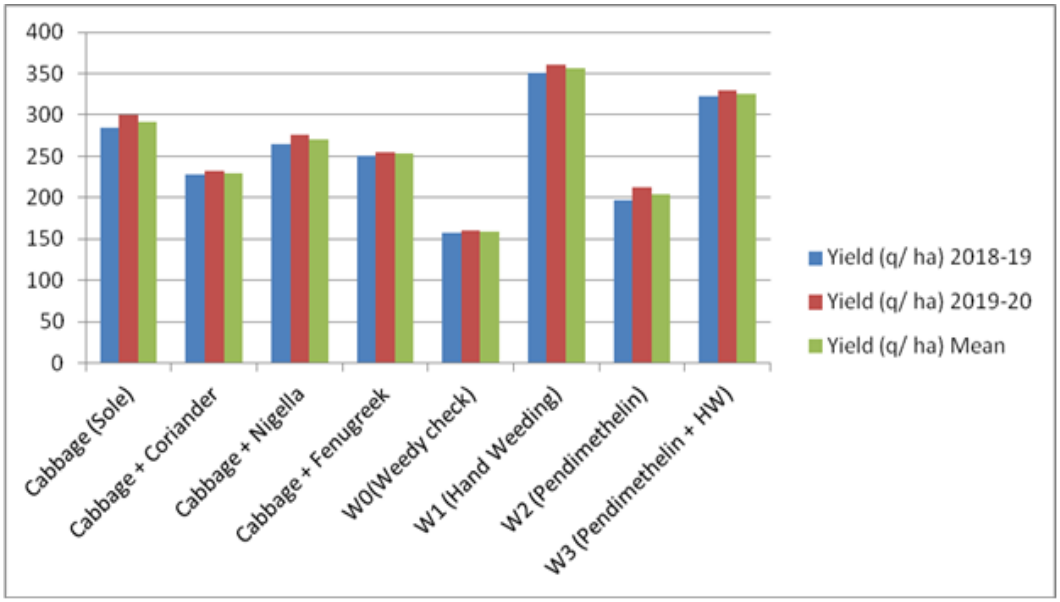

Fig 4: Shows in Cabbage (sole), cabbage+ coriander

Conclusion

It can be inferred from the above findings that the application of Pendimethalin PE @ 3.3 l/ha + one hand weeding at 30 days after sowing under cabbage + nigella intercropping is more effective to control the weeds and increasing the growth and yield of cabbage

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