Available online at www.notulaebiologicae.ro

Print ISSN 2067-3205; Electronic 2067-3264

Not Sci Biol, 2011, 3(3):113-119

Notulae Scientia Biologicae

Effect of Defoliation and Fe and Mn Spraying on Quality and Quantity Characteristics of Sunflower (*Helianthus annuus* L.)

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Abstract

The study was aimed at identifying the amount of reduction in the negative effects of leaf removal on both quality and quantity of sunflower as a result of foliar application of Fe and Mn. Severe leaf removal reduced the seed yield and seed weight to 11% and 10.5% respectively. The use of Fe in comparison to control increased the seed yield and seed weight up to 12% and 10% respectively. The use of Mn in comparison to control caused an increase in seed number up to 11.6% but caused a reduction in seed weight to 10%. The use of Fe in normal foliar defoliation treatment (40% defoliation) caused a significant increase in seed yield but no significant effect was observed in sever defoliation treatment (80% defoliation). Although using Mn in all treatments led to a rise in seed yield, the effect was not significant, it could be concluded that the combined use of Mn and Fe had no significant influence on sunflower yield, so there might be an antagonistic effect between the two.

Keywords: defoliation, Fe, Mn, spraying, sunflower

Introduction

In many countries sunflowers (*Helianthus annuus* L.) are mainly grown for their edible oil or their nuts used as a snack. The main objective in crop production is to obtain high yielding and high quality crop. Achievement of this goal requires the use of appropriate cultivar for a particular region, high quality seed and application of proper management practices (Majid and Schnettier, 1987*)*.Oilseeds sowing has been an important part of the agriculture all over the world especially in the east for years and its production increase in the world confirms the importance of this issue. some countries have considerable potential or talent in oil seed production and some of oil seeds like castor and sesame have a long history, but for different reasons like dependence on oil industry and lack of suitable planning for agriculture priorities , this potential hasn't been exploited yet (Schneiter *et al*., 2002). The leaves of this plant are the first source of photosynthetic materials production needed for filling the seeds and any loss or lack of their efficiency results from factors such as pests, diseases, mechanical damages, hail. Reductions in translocation of photosynthetic materials to the seeds, and yield loss due to leaves'fall have important roles in yield prediction. Previous studies have showed that the reduction in leaf area caused by defoliation could reduce transpiration of wheat (Midmore *et al*., 2001; Zhu, 2001), maize (Crookston and Hicks, 1988) and soybean plants (Ostlie and Pedigo, 1984). Two aspects of plant physiology affected by defoliation are the relationship between the sink and the source in carbohydrate availability and modified water balance across the plant. Regarding the sink/source relationship, many researchers have focused on accurate and precise assessments of foliar diseases (Guan and Nutter, 2002). They have evaluated the yield and quality effects of defoliation on forage production to improve the ability of agronomists, farmers and crop insurance adjusters to assess the economic impacts of leaf damage (Roth and Lauer, 2008). Models have been developed for a range of crops that simulate the impact of defoliation caused by pests on crops (Kropff *et al*., 1995; Olesen and Grevsen, 2000). In these models, the balance of carbohydrates between the source and sink organs was assessed based on empirical data from defoliated plants. Empirical experiments for wheat showed that during the vegetative period, defoliation at early and middle tillering did not affect seed yield, while defoliation imposed at late tillering and at booting reduced seed yield under rain-fed conditions (Zhu, 2001; Zhu *et al*., 2004). Providing the proper fertilization from the soil with a balanced supply of chemical fertilizers and plant nutrient elements is one of the important aspects of crop management to achieve maximum yield and high quality crops and minimize their harmful effects on the environment (Chaudhry *et al*., 1999). Crop plants need to have multiple nutrients for optimal growth and development and some elements such as nitrogen, phosphorus and potassium in relatively large quantities are needed and the lack of these elements in soil will reduce plant growth and production (Schneiter *et al*., 2002). Defoliation experiments to simulate the damage caused by diseases, pests and hail come into force. Performing such experiments shows the role of leaves in supplying and transferring pho-

Received 08 April 2011; accepted 21 July 2011

tosynthetic materials in different stages of plant growth. In addition to the critical growth stages of defoliation caused by adverse climatic and environmental factors also certainly clear that defoliation is effective on farm management (Schneiter and Johnson, 1994). The use of micro elements can somehow reduce stress. Negative effects of defoliation on plants are both quantitative and qualitative. And the use of micro elements can reduce the negative effects of leaf removal. We have taken a step up in order to optimize use of micro-elements.

Material and methods

A field experiment was carried out at Islamic Azad university research farm in Gonabad (latitude: 34°21' N; longitude: 58°41' E; rainfall average: 142 mm). The soil in the experimental plot is clay loam with pH 7.8, containing total N (703 ppm), total P (2 ppm), and total K (0.23 ppm), with an EC of 10 mmhos cm^{-1}. The experiment was carried out in a factorial design based on randomized complete block with three replications. Defoliation was imposed using shears at three levels of defoliation 0 (control), 40 and 80% of the leaf surface area. The defoliation method described by Muro *et al.* (2001) was used. Treatments included Fe in two levels (with and without Fe) and Mn in two levels (with and without Mn). Fe and Mn fertilizers were provided by chelate and manganese sulphate (in two stages of head stared and seed formation) respectively. Sowing was performed in rows 70 cm apart; plant distance within the row was 40 cm. Each row had 12 plants with each plot consisting of 6 rows. Irrigation was done when the available moisture reached 20% of field water capacity. At harvest time, the plants in the two middle rows(a total of 24 plants)were collected and taken to the laboratory and yield parameters were determined after the heads had been threshed and the seeds had been dried to a moisture content of about 7%.

The following parameters were examined:

100-seed weight: 100-seed samples were taken 5 times from each plot and weighed.

Seed yield: seeds of all plants from the harvested area were weighed. Then each plot yield was measured and described in g/m^2.

Oil percentage: oil percentage was determined by the Soxhlet method after extraction with petrol ether.

Plant height: average of plant height were measured in cm.

Biological yield: Dry weight of plants in each plot was calculated and described as biological yield in g/m^2

Number of seeds per head: Number of seeds per head were taken 5 times from each plot and were counted.

Result and discussion

The results showed that severe defoliation significantly reduced seed yield (Tab. 6). Compared with control, severe leaf removal decreased the seed yield to 11 percent (Tab. 5). Fe application had a significant effect on seed yield, while the effect of Mn on seed yield wasn't significant (Tab. 6). The use of Fe in comparison to control increased seed yield by 12 percent (Tab. 4). Defoliation did not affect the number of seeds per head, but the 100-seed weight significantly declined. It seems that number of seed per head is controlled genetically while seed weight depends on the source strength. Hence removal of leaf resulted in source limitation, and consequently seed weight decreased (Tab. 6). In comparison to control, heavy removal of leaf resulted in 10.5 percent seed weight decrease (Tab. 5). Fe spraying had a significant effect on seed weight (Tab. 6). As compared with the control, Fe effect on 100-seed weight increased by 10 percent (Tab. 4). Mn application had a significant effect on seed number per head and 100-seed weight (Tab. 6). Mn application as compared with the control increased seed number per head by 11.6% and

Tab. 1. Long-term (1978-2008) meteorological data in Gonabad, Iran

	Average of temperature(^{0}C)		Monthly total of precipitation (mm)	Average of relative humidity (%)	
	maximum	minimum		maximum	minimum
Jan	0.5	-9.6	54.2	66	62
Feb	3.7	-7.6	29.4	53	37
Mar	15	4	0	43	28
Apr	18.2	7.8	78.5	58	43
May	24.3	12.3	16.8	36	28
June	28.6	16.4	6.5	27	21
July	30.5	19.3	0	26	21
Aug	28.4	16.6	0	25	19
Sep	26.6	14.3	0	22	18
Oct	19.5	7.4	0.3	30	21
Nov	18.2	6.7	0	34	18
Dec	10.9	1.8	31.7	58	39
Annual/Mean	18.7	7.4	217.4	42	30

reduced the seed weight by 10% (Tab. 3). Fig. 1 shows that when there is a sink restriction (600 seeds per head), an increase in the availability of Fe had a slight role in yield increase but when there is no limitation in sink size (1000 seed per head), providing Fe resulted in an increase in seed yield (open graphs in this section). This shows that Fe provision cannot compensate for the decrease in sink size (due to the negative effect of reducing leaf area on the sink size or Mn deficiency), but when the sink power increased (the percentage of fertile florets was high in head), the use of Fe could compensate for the deficiency of sink by increasing the source power (photosynthetic ability of leaves, chlorophyll synthesis) compensate. It seems as if Fe unlike Nitrogen fails to prevent florets abortion and reduce the size of sink, but if the number of sinks is increased (the high number of seed in head) an increase in leaf photosynthesis (chlorophyll) can provide the needed photosynthesis materials for head and this prevents empty seed production. But according to Fig. 2, Mn and fe had an antagonistic effect on each other so that by increasing the sink size (800 seeds per head or more), Mn availability caused a significant reduction in seed yield (the lines diverge from each other) leaf removal and Mn spraying had a significant effect on seed weight (Tab. 5). Compared with control, the use of Mn caused a 24% reduction in seed weight (Tab. 3). Defoliation had a significant effect on oil percentage and plant height (Tab. 5), so that compared with control; severe defoliation caused a 37% and 6.5% decrease in oil and plant height respectively (Tab. 2). In Fig. 4 when the number of seeds per head was low(size of a small sink), the use of Mn and Fe (F_1M_1) together has increased seed yield in comparison to the lack of Fe and Mn condition (F_0M_0), which itself could compensate for the reduced seed number per head through seed weight increase (Fig. 5). Fig. 5 show that when the seed weight is low, the use of Fe and Mn (F_1M_1) led to an increase in seed yield (open curve) in comparison to the lack of Fe and Mn (F_0M_0). But when the seed weight is high, seed yield difference

Tab. 2. Interaction effects of defoliation and Fe applications on oil percentage, biological and seed yield, yield components and plant height of sunflower

		Seed yield ($g\ m^{-2}$)	Biological yield ($g\ m^{-2}$)	NSH	SW (g)	HW (g)	Oil percent (%)	Plant height (cm)
D_0	F_0	296.37	1181.98	974	5.71	130.60	11.25	151.55 a
	F_1	263.60	902.03	860	5.79	86.40	9.75	136.56 b
D_1	F_0	176.57 b	722.87	736 b	4.47 b	84.85	11.50	119.72 b
	F_1	326.91 a	828.70	1051 a	5.84 a	92.86	11.50	141.42 a
D_2	F_0	255.55	604.28	908	5.26	60.82	137.07	17.00
	F_1	242.78	499.12	867	5.26	43.84	17.25	141.05

D_0=no defoliation, D_1=40% defoliation, D_2=80% defoliation; F_0=no Fe application. F_1= Fe application; NSH=Number of seed per head, SW= 100 seed weight, HW=Head weight

Tab. 3. Interaction effects of defoliation and Mn applications on oil percentage, biological and seed yield, yield components and plant height of sunflower

		Seed yield ($g\ m^{-2}$)	Biological yield ($g\ m^{-2}$)	NSH	SW (g)	HW (g)	Oil percent (%)	Plant height (cm)
D_0	M_0	303.32	1228.62	875	6.40a	132.32	7.50	152.44a
	M_1	256.95	855.90	952	5.10b	84.68	13.50	135.67b
D_1	M_0	237.35	796.25	891	5.24	103.17	13.00	131.22
	M_1	265.63	755.32	958	5.07	74.54	10.00	129.91
D_2	M_0	226.02	495.58	809b	5.16	47.83	16.25	135.87
	M_1	271.31	607.82	966a	5.36	56.83	18.00	142.25

D_0=no defoliation, D_1=40% defoliation, D_2=80% defoliation; M_0=no Mn application. M_1=Mn application; NSH=Number of seed per head, SW= 100 seed weight, HW=Head weight

Tab. 4. Interaction effects of Fe and Mn applications on oil percentage , biological and seed yield, yield components and plant height of sunflower

		Seed yield ($g\ m^{-2}$)	Biological yield ($g\ m^{-2}$)	NSH	SW (g)	HW (g)	Oil percent (%)	Plant height (cm)
F_0	M_0	240.01	946.02	791	5.47	104.70	11.33	139.25
	M_1	245.84	726.74	955a	4.82	79.49	15.16	132.98
F_1	M_0	271.11	733.95	890	5.73	84.18	13.16	140.44
	M_1	283.42	752.62	962	5.54	64.55	12.50	138.90

F_0=no Fe application. F_1=Fe application; M_0=no Mn application; M_1=Mn application; NSH=Number of seed per head, SW= 100 seed weight, HW=Head weight

Tab. 5. Interaction effects of defoliation and Fe and Mn applications on oil percentage, biological and seed yield, yield components and plant height of sunflower

			Seed yield (g m^{-2})	Biological yield (g m^{-2})	NSH	SW (g)	HW (g)	Oil percent (%)	Plant height (cm)
D_0	F_0	M_0	307.08	1591.22	876	6.37a	166.96	7.0	164.75
		M_1	285.25	772.75	1073	5.05b	94.25	15.5	138.35
	F_1	M_0	299.55	865.02b	890	6.43a	97.69	8.0	140.13a
		M_1	227.64	939.05a	829	5.16b	75.11	11.5	133.00b
D_1	F_0	M_0	163.34	654.70	635	4.77	84.10	16.0a	113.95b
		M_1	190.80	791.05	837	4.18	85.61	7.0b	125.50a
	F_1	M_0	312.37	937.80	1024	5.72	122.25	10.0	148.50
		M_1	341.45	719.60	1077	5.97	63.47	13.0	134.32
D_2	F_0	M_0	250.63	592.15	862	5.28	63.04	11.0	139.05
		M_1	261.47	616.42	953	5.24	58.60	23.0	135.10
	F_1	M_0	202.41	399.02	755	5.04	32.62	21.5a	132.70
		M_1	282.16	599.22	978	5.49	55.07	13.0b	149.40

D_0=no defoliation, D_1=40% defoliation, D_2=80% defoliation; F_0=no Fe application. F_1=Fe application; M_0=no Mn application; M_1=Mn application; NSH=Number of seed per head, SW= 100 seed weight, HW=Head weight

Tab. 6. Mean squares of ANOVA for oil percentage, biological and seed yield, yield components and plant height of sunflower

Soy	df	Seed yield	Biological yield	NSH	SW	HW	Oil percent	Plant height
D	2	*	**	ns	**	**	**	**
Fe	1	*	ns	ns	**	ns	ns	ns
Mn	1	ns	ns	**	**	*	ns	ns
D*Fe	2	**	ns	**	**	ns	ns	**
D*Mn	2	*	ns	ns	**	ns	ns	**
Fe*Mn	1	ns	ns	ns	ns	ns	ns	ns
D*Fe*Mn	2	ns	*	ns	ns	ns	**	**
Error	22							

** P < 0.01; * P < 0.05; ns P > 0.05; D=Defoliation, NSH=Number of seed per head, SW= 100 seed weight, HW=Head weight

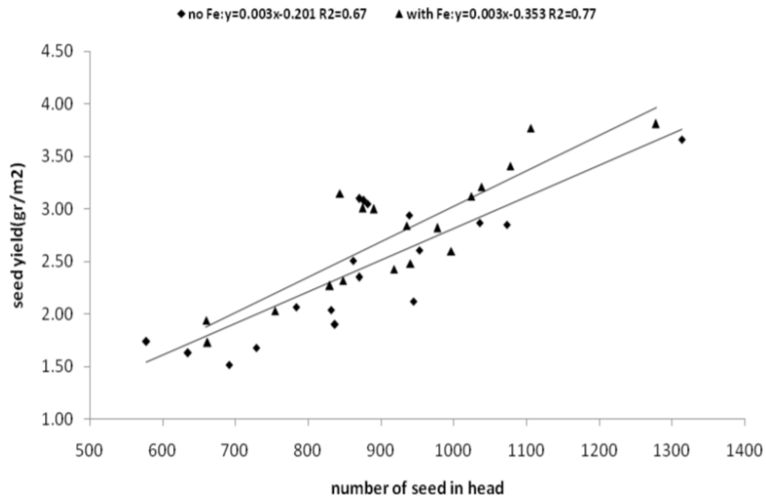

Fig. 1. Relationship between seed yield and number of seed per head in case of Fe (with Fe) and without Fe (no Fe) application in sunflower

becomes less (closed curve). Based on Fig. 1, the role of Fe alone was greater when the numbers of seeds per head was larger (larger sink size) and increases seed yield compared to control. Mn alone could cause changes in seed yield when the seed number per head was between 550 to 600 or more (Fig. 2). While because of the antagonistic effect between the two (Fig. 4). When we use Mn with Fe, changes in seed yield occurred when the seed number per head was between 700 to 750 . Due to the antagonistic effect between the two, when Mn is used alone, seed yield changes happened when the 100 seed weight was between 7.5 to 8 g (Fig. 3), whereas when we use Mn with Fe , this change happens when the 100 seed weight was between 6.5 to 7 g.

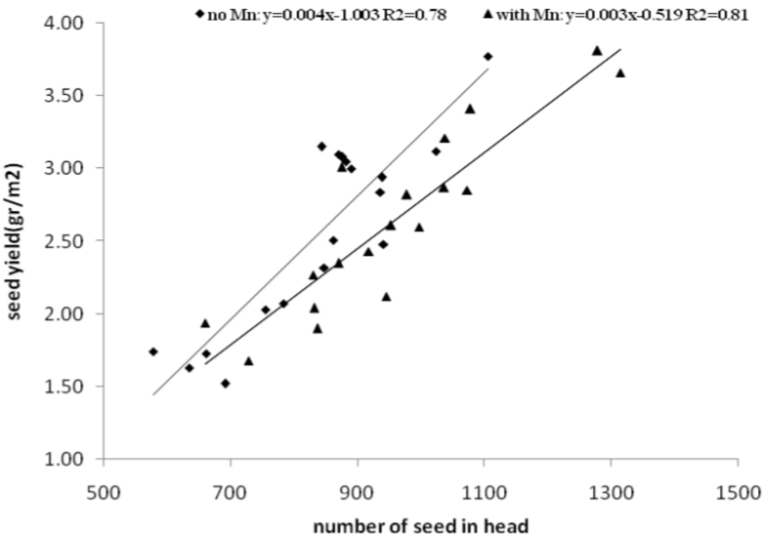

Fig. 2. Relationship between seed yield and number of seed per head in case of Mn (with Mn) and without Mn (no Mn) application in sunflower

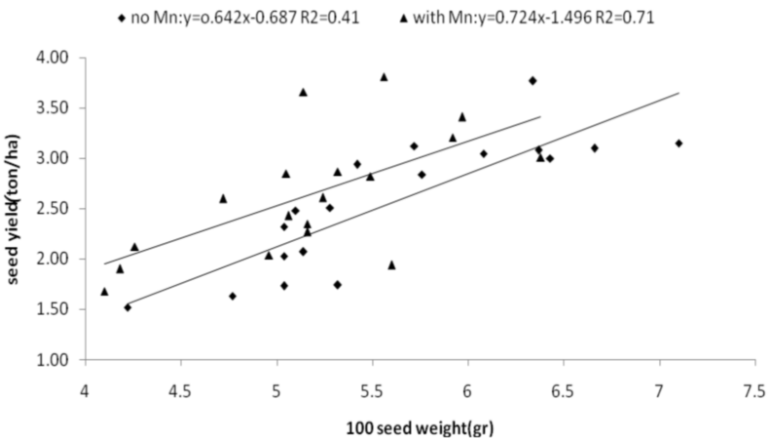

Fig. 3. Relationship between seed yield and 100 seed weight in case of Mn (with Mn) and without Mn (no Mn) application in sunflower

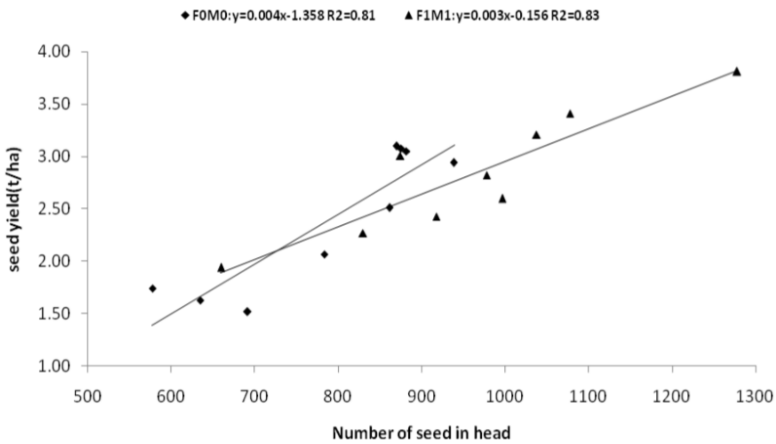

Fig. 4. Relationship between seed yield and number of seed per head in case of Mn and Fe(F_1M_1) together, and lack of Mn and Fe(F_0M_0)

Fig. 5 shows that when the sink size is small (low number of seeds per head), defoliation effect was more severe on seed yield, but when numbers of seeds per head increased, defoliation had little effect on seed yield, which seems reasonable because of the large sink due to a positive effect of the sink size on power source. The remaining leaves pho-

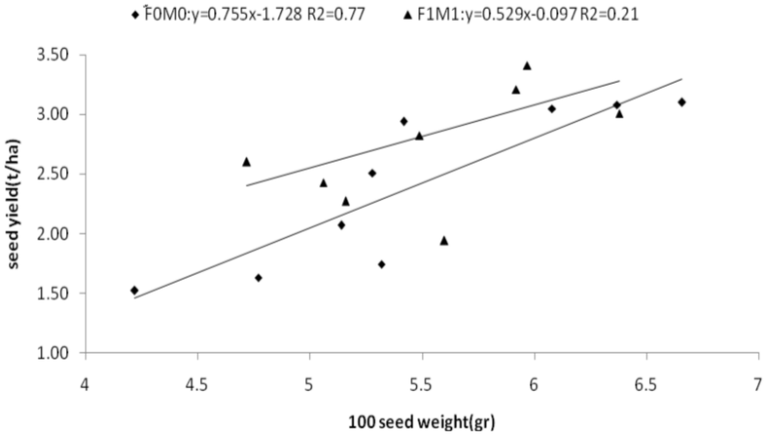

Fig. 5. Relationship between seed yield and 100 seed weight in case of Mn and Fe (F_1M_1) together, and lack of Mn and Fe (F_0M_0)

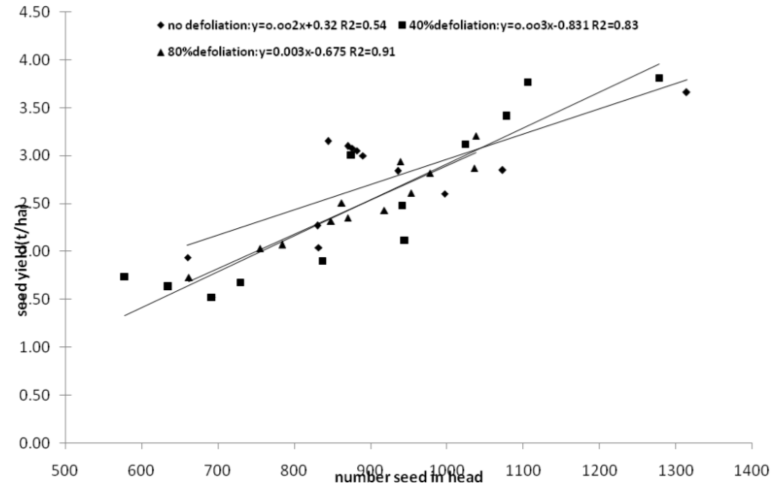

Fig. 6. Relationship between seed yield and number of seed per head at different defoliation treatments in sunflower

tosynthesis (in defoliation treatments) increased, which compensated for the decreased number of leaves, but at low seed number per head (due to reduced negative effect of sink size on power source), remaining leaves will have little photosynthesis.

Correlation between seed number per head and seed yield was not significant (R^2=54) in the case of no defoliation while this correlation was significant when the defoliation was done (R^2=91). It seems that defoliation caused the source limitation hence an increase in seed number did not affect the seed yield (Fig. 6).

Conclusions

Results indicated that when Fe was used alone, seed yield increased because of an increase in seed weight, but for Mn seed yield was not affected, since seed number per head increased while seed weight and head weight decreased. The use of Fe in normal defoliation treatment (40%) increased seed yield significantly, but in severe defoliation treatment (80%) it had no significant effect on seed yield. Although the use of Mn in all defoliation treatments increased seed yield it was not significant. It can be concluded from the results that the combined use of Mn and Fe had no significant impact on sunflower yield so there might be an antagonistic effect between the two elements.

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