Effect of different sowing timeand cultivars on oilcontent, yield attributes andyield of safflower

Abstract

The present experiment was carried out at All India Coordinated Research Project on safflower, College of Agriculture, Indore, (M.P.) during *rabi* season 2015-16 to study the effect of date of sowing and cultivars on number of capitula plant^{-1}, total seed weight, 100 seed weight, seed yield, biological yield, straw yield, harvest index, oil content and oil yield.The experiment was performed in split plot design using three sowing dates and three cultivars. The maximumcapitula (31.26plant^{-1}) andtotal seed weight(25.11 gplant^{-1})wererecorded with 1st November sown crop.The cultivar A-1 registered the highest 100 seed weight (5.42 g) which wassignificantly superior over cultivar NARI-6 and NARI-57.The highest seed yield (1565.42 kg ha^{-1}), straw yield (7771 kg ha^{-1}) and biological yield (9336.42 kg ha^{-1}) were obtained under 1st November of sowing. The maximum oil content (35.36 %) was received with NARI-57 followed by NARI-6 and A-1.The highest oil yield (509.35 kg ha^{-1}) was observed with 1stNovembersown crop. Based on the findings it is concluded that for obtaining maximum yield of safflower, use of A-1 cultivar and sowing done at 1st November is recommended.

Keywords: Safflower,capitula,harvest index, yield and oil content.

1. INTRODUCTION

Safflower [*Carthamustinctorius*(L.) Moench] is one of the important rainfed and drought tolerant *rabi* oilseed crop. Generally, it is known as *kusum*or*kardi.* Safflower is a member of family compositae, cultivated mainly for its seeds, which yield edible oil. It is a highly branched, thistle-like annual or winter annual herb, usually with many long sharp spines on the leaves and stems. Plants are 30-150 cm tall with globular flower

heads (capitula) and commonly brilliant yellow, orange or red flowers. The plant has a strong taproot which enables it to thrive in dry climates.

In India, safflower is grown only as rainfed, winter crop on residual soil moisture. Also generally it is intercropped with cereals such as wheat and sorghum. The safflower production in the country during 2013-2014 is 178 thousand ha with total production of 114 thousand tones with 640 kg/ha.In Madhya Pradesh safflower crop is grown mainly in *rabi* season and covers an area of 0.18 thousand ha with total production of 0.13 thousand tones [1]. Its cultivation is becoming popular in Madhya Pradesh due to its high yield potential particularly under limited moisture conditions [2]. The average production of safflower in India and Madhya Pradesh is too low. Among various factors which contributes to increase the safflower yield in per unit area, the most economical and possible set of practices a farmer can adopt, is the use of most suitable variety, planted at proper time, together with other cultural practices.

In the recent past, extensive research on climate change predicts marked increase in temperature. India's average temperature has inched up by around 0.7°C during 1901–2018 [3] and considered as one of the important factors responsible for low yield in wheat. The low production of safflower in Madhya Pradesh is due to shorter favourable growing period, high temperature with low humidity and short cool spell during growing season with more fluctuation in temperature. The optimum sowing date depends on rainfall and temperature to maintain high grain yields. Under timely sown condition, safflower crop revived prolonged favourable growth environment and resulted in higher accumulation of carbon photosynthates which ultimately enhanced higher values of yield attributes including grain yield [4]. Therefore, the optimization of sowing time is an important parameter to attain maximum yield and efficient conversion of biological yield into economic yield.

Selection of location specific variety is one of the most essential agronomic activities [5]. Variety change has played a key role in improving productivity, according to Chen et al. [6] with the contribution of cultivar to yield rising from 21.0% to 44.3% during the last 50 years. Currently, many varieties have been evolved and each needs specific management practices and climatic requirements on which it reaches its full

genetic potential [5]. Therefore, a comparison of varieties for growth and yield characteristics under various sowing regimes is necessary [7].

By considering the above facts, the experiment was carried out with the objective to test different safflower varieties under different sowing time for achieving better germination, emergence and rosette termination.

2. MATERIALS AND METHODS

2.1 Chemical analysis

The pH of soil was determined by using glass electrode pH meter using 1**:**2 soil water suspensions at 25°C. The supernated liquid of the soil suspension formerly used for pH determination was also used for the determination of electrical conductivity by conductivity meter in 1**:**2 soil water suspensions at 25°C and expressed as dSm^{-1}. Organic carbon was estimated by wet digestion method as explained by Walkley-Black [8] method. In this method organic matter in the soil is oxidized with a mixture of potassium dichromate ($K_2Cr_2O_7$) and concentrated H_2SO_4 utilizing the heat of dilution of H_2SO_4. Unused $K_2Cr_2O_7$ is back titrated with ferrous ammonium sulphate. The available nitrogen in soil was determined by alkaline permanganate method as explained by Subbian and Asija [9]. The estimation of available P_2O_5 was done by using Olsen's extract (0.5 m sodium bicarbonate solution of pH 8.5) as described by Olsen *et al*. [10]. The available amount of potassium was determined by using N neutral ammonium acetate as mentioned by Jackson [11].

Table1 Chemical analysis of the experimental soil

Analysis	**Values**
Soil pH	7.55
Electrical conductivity (dsm^{-1})	0.43 (dsm^{-1})
Organic Carbon (%)	0.39 %
Available Nitrogen ($kg\ ha^{-1}$)	232 $kg\ ha^{-1}$
Available phosphorus ($kg\ ha^{-1}$)	12.2 $kg\ ha^{-1}$
Available potash ($kg\ ha^{-1}$)	496 $kg\ ha^{-1}$

Table2 Different soil properties and methods employed for analysis

Sr. No.	Soil property	Method followed
1.	Soil pH (1:2.5)	pH meter
2.	EC (1:2.5) (dS/m) at 25 °C	EC meter [11]
3.	Organic carbon (%)	Walkley and Black's method [8]
4.	Available N (kg ha^{-1})	Alkaline $KMnO_4$ method [9]
5.	Available P_2O_5 (kg ha^{-1})	Olsen's method [10]
6.	Available K_2O (kg ha^{-1})	Flame photometric method [11]
	Mechanical analysis	
7.	Sand (9.56%)	Bouyoucos hydrometer method [12]
8.	Silt (34.32%)	
9.	Clay (56.12%)	

2.2 Method of fertilizer application and sowing

In experimental plot furrows were opened with the help of small *kudali*at a distance of 45 cm from each other. The calculated quantities of fertilizer as per treatment were applied plot wise. The amount of nutrient was given through complex fertilizer (IFFCO grade 12**:**32**:**16) was used for supplying nitrogen, phosphorous and potash. The remaining amount of nitrogen was applied through urea. The recommended dose of fertilizer (60 N + 40 P_2O_5 + 20 K_2O kg ha^{-1}) was applied in safflower. Full dose of P_2O_5, K_2O and half dose of N were applied at the time of sowing in the furrow below the seed. Remaining half dose of N was applied at stage of crop at 45 DAS. The required quantity of seed was placed in furrows manually and covered with soil immediately. In order to get good tilth of soil for sowing, the experiment field was cultivated once with the tractor drawn cultivator and one harrowing by bullock drawn harrow followed by planking to level the field. For ensuring good germination, healthy and good quality seeds were used with 20 kg ha^{-1}.The seed of safflower was treated before sowing with Thiram @ 2.5 g kg^{-1} seed. In experimental plot furrows were opened with the help of small *kudali*at a distance of 45 cm from each other. The calculated quantities of fertilizer as per treatment were applied plot wise. The amount of nutrient was given through complex fertilizer (IFFCO grade 12**:**32**:**16) was used for supplying nitrogen, phosphorous and potash. The remaining amount of nitrogen was applied through urea. The recommended dose of fertilizer (60 N + 40 P_2O_5 + 20 K_2O kg

ha^{-1}) was applied in safflower. Full dose of P_2O_5, K_2O and half dose of N were applied at the time of sowing in the furrow below the seed. Remaining half dose of N was applied at stage of crop at 45 DAS.

Annigeri (A-1): The average seed yield of this variety is 1600-1700 kg ha^{-1}. Oil content of this variety is 24-29 % and oil yield is 600-725 kg ha^{-1}. This variety matures in 120-140 days. It has moderately tolerant to aphid. This variety is mainly grown in regions of Karnataka, Bihar, Orissa and Rajasthan.

NARI-6: The average yield of this variety is 1000-1100 kg ha^{-1}. Oil content of this variety is 26-32 % and oil yield is 550-650 kg ha^{-1}. This variety matures in 135-145 days. It has tolerant to foliar and wilt disease such as Alternaria and cercospora. NARI-6 is non spiny variety grown in regions of all over India. Flowers are dark red and flowers yield 70-80 kg ha^{-1}.

NARI-57: The average yield of this variety is 1300-1400 kg ha^{-1}. Oil content of this variety is 28-35 % and oil yield is 530-650 kg ha^{-1}. This variety matures in 130-140 days. NARI-57 is spiny variety grown in regions of all over India.

3. Results and discussion

3.1 Number of capitula $plant^{-1}$

Number of capitula per plantis important yield contributing character to judge the grain yield of safflower crop. The data on average number of capitula $plant^{-1}$ were analyzed statistically.Data presented in Table1,revealed that sowing dates showed a significant variation on number of capitula $plant^{-1}$.The maximum capitula (31.26)$plant^{-1}$ was recorded with 1stNovember sown crop, which was significantly superior over15thNovemberand 15th November sowing also gave significantly higher number of capitula/plantas compared to 30th November sown crop.The data presented in Table3, indicatedthatcultivars caused significant variation on capitula $plant^{-1}$.The maximum capitula (22.84)$plant^{-1}$ was recorded incultivarA-1 followed by NARI-57 (21.26) and minimum capitula recorded in cultivar NARI-6 (17.44).The data presented in Table3, indicatedthatcultivars caused significant variation on capitula $plant^{-1}$.The

maximumcapitula (22.84)plant^{-1} was recorded incultivarA-1 followed by NARI-57 (21.26) and minimum capitula recorded in cultivar NARI-6 (17.44).

The yield attributing characters viz.; number of capitula plant^{-1} andtotal seed weight g plant^{-1} were significantly influenced by different sowing dates, cultivars and their interaction.The sowing of crop on 1st November gave the highest number of capitulaplant^{-1}andtotal seed weight g plant^{-1}. Delay in sowing results generally decrease in the yield attributes. Increase in different yield attributing characters in 1st November sowing might be due to more availability of favorable environmental condition at the vegetative and reproductive phase of the crop and might be due to better uptake of nutrients and translocation of photosynthates during the reproductive phase of the crop, thus increasing the size and weight of seeds.The results are close conformity with the findings of Ddasi*et al* (13),Nikpporand Koocheki(14), Emami *et al.* (15)**.** Data showed that the yield attributing characters was affected significantly by cultivars. Higher number of capitula plant^{-1}, total seed weight plant^{-1} and 100 seed weight was obtained by cultivar A-1. The variation in these growth parameters of the cultivars might be related to inherent differences and high vigourof these cultivars.

3.2 Total seed weight (g plant^{-1})

The data in Table3, showed that the total seed weight (g plant$^{-1)}$ was affected significantly by different sowing dates. Maximum total seed weight plant^{-1} (25.11 g) was observed in the 1st November sown crop and minimum total seed weight (7.66 g) was found at 30th November crop. A perusal of data as evident from Table3, indicatesthat the maximum total seed weight (19.04 g) was recorded with A-1. Minimum total seed weight (12.86 g) was found with safflower cultivar NARI-6.

3.3 100 Seed weight (g)

The Table3, data showed that the 100 Seed weightwas notaffected significantly by the different sowing dates. However maximum 100 Seed weight(4.56 g) was obtained under the1st November date of sowing followed by 15th November sowing date.

The data presented in Table 3, indicated that cultivar caused significant impact on 100 Seed weight. The cultivar A-1 registered the highest 100 Seed weight (5.42 g)

was significantly superior over cultivar NARI-6 and NARI-57. Aakash et al. [**5**] also reported that yield attributes may vary depending on the genotype special ability for some traits.

Table 3.Impact of sowing dates and cultivars on numberof capitula plant^{-1}, total seed weight (g plant^{-1}) and 100 seed weight (g)

Treatments		Number of capitula plant^{-1}	Total seed weight (g plant^{-1})	100 seed weight (g)
Sowing dates	1 November	31.26	25.17	4.56
	15 November	19.99	14.00	4.23
	30 November	10.30	7.66	4.04
	SEm±	**1.30**	**0.78**	**0.13**
	CD at 5 %	**4.51**	**2.72**	**NS**
Cultivars	A-1	22.84	19.04	5.42
	NARI-6	17.44	12.86	3.42
	NARI-57	21.26	14.93	4.00
	SEm±	**0.68**	**1.50**	**0.11**
	CD at 5 %	**2.02**	**4.48**	**0.33**

3.4 Seed yield (kg ha^{-1})

Seed yield (kgha^{-1}) is the most economical character for evaluating the superiority of the treatment over the other. The imp activeness of any treatment could be judged by the magnitude of changes in the productivity potential of a crop responded to different treatments in the experiment.

The data presented in Table4(A), indicated that sowing dates brought about significant variation in seed yield. The highest seed yield (1565.42 kgha^{-1}) was obtained under 1st November sown crop,which was significantly higher over 15thNovemberand 15thNovembersown crop also gave significantly superior seed yield as compared to 30th Novembersown crop. A perusal ofdataas evident from Table4(A)**,** indicates that the maximum seed yield (1385.58 kgha^{-1})recorded with A-1, whichwas significantly higher over NARI-57. NARI-57 also recoded significantly highest seed yield as compared to NARI-6 cultivar. The differences in genotypic yield attributes due to higher leaf area were also observed by [5].

Maximumseed yieldrecorded with cultivar A-1, whichwas significantly higher over other cultivars.Such close association of seed yield with different yield components was

also observed by Muralidharudu*et al.* (16), Mohankumar *et al.* (17) and Annual report (18).

Table4(A) Impact of sowing dates and cultivars on seed yield, biological yield and straw yield (kg ha^{-1})

Treatments		Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Sowing dates	1 November	1565.42	9336.42	7771
	15 November	1215.08	7031.92	5816.83
	30 November	707.42	3400.33	2692.92
	SEm±	**66.90**	**342.20**	**286.06**
	CD at 5 %	**231.53**	**1184.21**	**989.93**
Cultivars	A-1	1385.58	7638.92	6253.33
	NARI-6	914.83	5776.83	4862
	NARI-57	1187.50	6352.92	5165.42
	SEm±	**37.74**	**120.86**	**105.34**
	CD at 5 %	**112.15**	**359.11**	**313.00**

3.4.1Interaction impact of sowing dates and cultivars

Among interaction of different sowing dates and different cultivars of safflower, the data presented Table4(B), indicated that cultivar A-1 recorded the highest seed yield (1833 kg ha^{-1}) with 1st November sown crop, which was followed by cultivar NARI-57 sown on 1st November (1665.25 kg ha^{-1}). All the cultivars performed significantly poorer seed yield on 30th November sowing over both the early dates.

Table4(B)Interaction impact of sowing dates and Cultivars on seed yield (kg ha^{-1})

	Cultivars (V)		
Sowing dates (D)	**A-1**	**NARI-6**	**NARI-57**
1 November	1833.75	1197.25	1665.25
15 November	1455	911.50	1278.75
30 November	868	635.75	618.50
	(D×V)1	**(D×V)2**	
SEm±	**65.37**	**85.59**	
CD at 5 %	**194.24**	**278.35**	

3.5Biological yield (kg ha^{-1})

The data showed that the safflower biological yield kg/ha was influenced significantly by the different date of sowing, different cultivars of safflower and there interaction. The

data presented in Table4(A),indicated that the highest biological yield (9336.42 kg ha^{-1}) was obtained under 1st November sown crop which was superior over 15th November and 15th November sown crop also gave significantly highest biological yield over 30th November sown crop. The data presented in Table4(A), showed that cultivar A-1 registered significantly higher biological yield (7638.42 kg ha^{-1}) over NARI-57 and NARI-57 also gave significantly highest biological yield over NARI-6 during the investigation. The results revealed significantly higher seed yield of safflower recorded by sowing on 1st November.

It was also observed that strawand biological yield were significantly higher by sowing at 1st November. The positive impact of date of sowing on straw yield and biological yield may be due to the pronounced growth during early stages of crop. It resulted in higher plant height and dry matter accumulation and ultimately tended in realization of higher straw and biological yields. The maximum oil content and oil yield was observed with 1stNovembersown crop.Thesowingdatein safflower delayed,oilyielddecreased.The findings are in close results with Kzl (19).

3.5.1Interaction impact of sowing dates and cultivars

Among interaction of different sowing dates and cultivar of safflower, the data presented Table4(C),indicated that cultivar A-1 recorded the highestbiological yield (10046.25 kg ha^{-1}) with 1st November sown crop, which was followed by NARI-57 sown on 1stNovember (9321 kg ha^{-1}). All the cultivars performed significantly poorer biological yield on 30th November sowing over both the early dates.

Table4(C) Interaction impact of sowing dates and cultivars onbiological yield (kg ha^{-1})

Sowing dates (D)	Cultivars (V)		
	A-1	NARI-6	NARI-57
1 November	10046.25	8642.00	9321.00
15 November	7963.00	6095.75	7037.00
30 November	4907.50	2592.75	2700.00
	(D×V)1	(D×V)2	
SEm±	**209.34**	**382.51**	
CD at 5 %	**622**	**1282.7**	

3.6 Straw yield (kg ha^{-1})

The data showed that the safflower straw yield (kg ha^{-1})plot was influenced significantly by the different sowing dates, different cultivars of safflower and there interaction.

The data presented in Table4(A), indicated that the highest straw yield (7771 kg ha^{-1}) was obtained under 1st November sown crop which was superior over 15th November, and 30thNovember sown crop. The data presented in Table4(A), showed that cultivar A-1 registered significantly highheststraw yield (6253.33 kg ha^{-1}) over NARI-57 and NARI-6 during the investigation. The data presented in Table4, showed that cultivar A-1 registered significantly highheststraw yield (6253.33 kg ha^{-1}) over NARI-57 and NARI-6 during the investigation

In case of straw yieldand biological yield the cultivar A-1 was found superior over other cultivars due to taller plant. Such close association of seed yield with different yield components was also observed by Muralidharudu*et al.* (16), Mohankumar *et al.* (17) and Annual report (18).

3.6.1 Interaction impact of sowing dates and cultivars

Among interaction of different sowing dates and cultivar of safflower, the data presented Table in 4(D), indicated that cultivar A-1 recorded the highheststraw yield (8212.50 kg ha^{-1}) under 1st November sown crop, which was followed by cultivar NARI-57sown on 1stNovember (7655 kg ha^{-1}). On 30th November date of sowing all the cultivar performed significantly poorer over both the early dates.

Table4(D)Interaction impact of sowing dates and cultivars on straw yield (kg ha^{-1})

Sowing dates (D)	Cultivars (V)		
	A-1	NARI-6	NARI-57
1 November	8212.50	7444.75	7655.75
15 November	6508	5184.25	5758.25
30 November	4039.50	1957	2082.25
	(D×V)1		(D×V)2
SEm±	182.45		322.52

CD at 5 %	**542.12**	**1079.19**

3.7Harvest index (%)

Harvest index is the ratio of economical yield to biological yield, which is expressed in term of percentage. The analysis of variance showed that harvest index was significantly influenced by the different sowing dates, safflower cultivars and there interaction.

The data presented in Table5.(A), indicated that the maximum harvest index (21.78 %) was recorded with 30thNovember sown crop followed by 15th November sown crop (17.18%).

Data presented in Table5(A), showed that cultivarNARI-57 registered significantly higher harvest index (19.74%) followed by A-1, NARI-6 18.06%, 17.81 % respectively.

Table5(A) Impact of sowing dates and cultivars onharvest index, oil content (%) and oil yield (kg ha^{-1})

Treatments		Harvest index	Oil content (%)	Oil yield (kg ha^{-1})
Sowing dates	1 November	16.66	32.55	509.35
	15 November	17.18	31.64	381.71
	30 November	21.78	29.51	210.23
	SEm±	**0.63**	**0.62**	**26.55**
	CD at 5 %	**2.20**	**2.16**	**91.89**
Cultivars	A-1	18.06	27.55	383.50
	NARI-6	17.81	31.21	287.56
	NARI-57	19.74	35.36	430.23
	SEm±	**0.53**	**0.45**	**13.05**
	CD at 5 %	**1.58**	**1.35**	**38.78**

3.7.1 Interaction impact of sowing dates and cultivars

Among interaction of different sowing dates and different cultivars of safflower, the data presented in Table5(B), indicated that cultivar NARI-6 recorded the maximum harvest index (24.55%) under 30**th** November sown crop which was followed by cultivar, NARI-57, sown during30thNovember (23.13%).

Table5(B) Interaction impact of sowing dates and

cultivars on harvest index

Sowing dates (D)	Cultivars (V)		
	A-1	NARI-6	NARI-57
1 November	18.25	13.81	17.91
15 November	18.28	15.08	18.17
30 November	17.66	24.55	23.13
	(D×V)1	(D×V)2	
SEm±	0.92	0.98	
CD at 5 %	2.74	3.10	

4 Oil content and Oil yield Parameter

4.1 Oil content (%)

The data indicated in Table5(A), that oil content of safflower was significantly influenced by different sowing dates. The maximum oil content (32.55 %) was observed with 1stNovembersown crop followed by 15thNovember and 30thNovember sowing.A perusal of datatable5(A),indicated thatdifferent cultivar registered a significant variation in oil content of safflower. The maximumoil content (35.36 %) was received with NARI-57 followed by NARI-6 and A-1.

It was observed maximum oil content was obtained in combination of cultivar NARI-57 with 1st November sowing.Such close association of oil content with different sowing date and cultivars components was also observed by Belgin *et al.* (20).

4.1.1 Interaction impact of sowing dates and cultivars

The data presented in Table6, revealed that sowing dates and safflower cultivarscombinations were found the significantly impact on oil content. Safflower CultivarNARI-57 was given the maximumoil content**(**37.21 %) on 1stNovember sowing as compared to other treatment combinations.

Table6Interaction impact of sowing dates and Cultivars on oil content

Sowing dates (D)	Cultivars (V)		
	A-1	NARI-6	NARI-57
1 November	28.71	32.08	37.21

15 November	26.22	31.51	36.86
30 November	27.73	30.06	32.02
	(D×V)1	**(D×V)2**	
SEm±	**0.78**	**0.89**	
CD at 5 %	**2.34**	**2.85**	

4.2 Oil yield (kg ha^{-1})

The data indicated in Table5(A), that oil yield of safflower was significantly influenced by different sowing dates. The highest oil yield (509.35kg ha^{-1}) was observed with 1stNovembersown crop followed by 15thNovember and 30thNovember sowing.A perusal of datatable5(A),indicated thatdifferent cultivar registered a significant variation in oil yield of safflower. The highest oil yield (430.24 kg ha^{-1})was received withNARI-57followed by A-1 andNARI-6.

4.2.1 Interaction impact of sowing dates and cultivars

The data presented in table7, revealed that sowing dates and safflower cultivarscombinations were found the significantly impact on oil yield. Safflower CultivarNARI-57was given the maximumoil yield(617.05kg ha^{-1}) in 1stNovember sowing as compared to other treatment combinations.

Table7 Interaction impact of sowing dates and cultivars on oil yield (kg ha^{-1})

Sowing dates (D)	**Cultivars (V)**		
	A-1	**NARI-6**	**NARI-57**
1 November	527.63	383.39	617.05
15 November	381.81	287.40	475.92
30 November	241.07	191.90	197.73
	(D×V)1	**(D×V)2**	
SEm±	**22.60**	**32.33**	
CD at 5 %	**67.17**	**106.26**	

Conclusion

The choice of location specific variety has advantages over other varieties since it well adopted and responded better to local environment/growing conditions and applied inputs leading to significant higher production. The maximumcapitula (31.26)plant^{-1} was recorded with 1st November sown crop, Maximum total seed weightplant^{-1} (25.11 g) was observed in the 1st Novembersown crop. The cultivar A-1 registered the highest 100 Seed weight (5.42 g) wassignificantly superior over cultivar NARI-6 and NARI-57.The highest seed yield (1565.42 kg ha^{-1}) was obtained under 1st November sown crop. The highest biological yield (9336.42 kg ha^{-1}) was obtained under 1st November sown. The highest straw yield (7771 kg ha^{-1}) was obtained under 1st November sown.that the maximum harvest index (21.78 %) was recorded with 30thNovember sown**.**The maximum oil content (35.36 %) was received with NARI-57 followed by NARI-6 and A-1.The highest oil yield (509.35 kg ha^{-1}) was observed with 1stNovembersown crop.

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