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Improvement of Quantities and Qualitative Characteristics of *Bunium Persicum* Germplasm Masses

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ABSRACT

In order to determine the relationship between yield and physiological and phenological traits and to understand the direct and indirect effects of various parameters on the yield, this experiment was conducted on 13 genotypes of Buniumpersicumin three times in a randomized block design in plots of 4 m x 5 m in Mashhad. Result showed that the genotype Khajeh forest was significantly superior with regard to number of seed umblet-1, seed yield, bio yield and yield of essential oil. Analysis of variance showed a significant difference at p<0.05 for different traits as plant height, seed weight, total weight per plant, number of seeds per plant, number of umbels per plant, seed, umblet in umbel, number of branches, 1000 seed weight, biological yield, seed yield, essential oil percentage, essential oil yield and harvest index among accessions. Range heritability estimates were recorded from 0.53 – 0.96 for all the traits except for plant height with moderate heritability. High heritability was observed for a number of characters. Genetic path coefficient analysis revealed that appearance of the seed weight per plant traits and the total weight of each plant had the highest positive direct effect on yield, and essential oil percentage had the highest negative direct effect on essential oil yield. Path way analysis of some of traits could not be entered in the model in despite a significant correlation with essential oil. Genetic path coefficient analysis revealed that appearance of the seed weight per plant traits and the total weight of each plant had the highest positive direct effect on yield, and essential oil percentage had the highest negative direct effect on essential oil yield.

1. Introduction

Black caraway (Bunium persicum Boiss.) is a perennial aromatic and medicinal herb, distributed in temperate areas of the world and mostly restricted to the sub- alpine mountain slopes (Dar *et al.* 2011). Its species grow wild in North Himalayan regions, Iran, Pakistan and generally it is native to central and Southern parts of Asia, with a wide geographical distribution in Iran. At present, seeds of this valuable medicinal spice plant are extensively collected from natural habitats (Khosravi 2005), in forests and grasslands in India, at higher elevations including arid zones ranging from 1600 m to 3300 m above sea level. In Iran, it is distributed at higher elevations, such as mountains which are colder than surrounding lowlands mainly in the North-East as in Semnan Qazvin, Hormozgan, Esfahan, Razavi Khorasan, Yazd, Fars, Arak and Kerman (Khosravi 2005; Ghasemi Arian *et al.* 2009). The crop mostly grows as wild under natural conditions in mountain, open hilly grassy slopes, low alpine and table lands, as sub – populations, mostly across the hilly areas. The sub-populations across the state represent a great diversity of this plant species, which is naturally maintained as valuable germplasm repositoriesو and are the sources of high genetic variability. The chemical composition of the essential oil were found as the major constituents from the fruits of Buniumpersicum identified as cuminaldehyde (27.0%), γ-terpinene (25.8%), p-cymene (12.1%), cuminyl alcohol (6.0%) and limonene (5.1%)(Foroumadi *et al.* 2002).

The most important of objectives of breeders is to increase the seed yield. Generally, yield represents the

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final character resulting from many developmental and biochemical processes (Mishra & Tewari 2014), which occur from germination and maturity. Before yield improvements, the breeder needs to identify the causes of variability in yield in any given environment. Since fluctuation in environment generally affects yield primarily through its components. Grafius(1960) suggested that individual yield components may contribute valuable information in breeding for yield. Yield when viewed from the mechanistic or geometric point of view is a product of its components. Knowledge of genetic variability in a given crop is essential for successful breeding improvement programme. To develop of high yielding cultivars, it requires a thorough knowledge of the existing variability and association for yield contributing traits in the available germplasm. This will enable him to know how the selection pressure exerted by him on one trait will cause changes in other traits (Al-Aysh *et al.* 2014). Base of Azmizadeh et al's assessments(2012), the heritability of the morphological traits in Buniumpersicum germplasms was high and the ecotypes exhibited the high genetic variations from the viewpoint of coefficient of variations.

The correlation and path coefficient analysis showed that seed yield per plant is positively associated with all the traits except seed per primary and secondary umbels. Primary umbels per plant, secondary umbels per plant and straw yield per plant were the most important parameters contributing to seed yield per plant in caraway crop (Mittal *et al.* 2006). The present study was conducted with an objective to estimate genetic variability with the aid of genetic parameters such as genotype coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h), genetic advance, the direct and indirect effects of each trait.

2. Materials and Methods

The present investigation was taken up to elicit information for various morphological, yields and yield attributing traits of Black caraway. The study was carried out during 2010 and 2015 in Mashhad. Mashhad features a steppe climate (KöppenBSk) with 250 mm annal precipitation, hot summers and cool winters. The seeds and bulbs of plant populations (22in total) of Black Caraway were collected from the wild areas of provinces of Semnan (the mountain ZAR Damghan), Qazvin (Alamut mountain), Hormozgan (Geno mountain Bandar Abbas), North and South (Santa Aman mosque, Esfahan, Razavi Khorasan (a mountain of Akhlamad, Kashmar, Bajestan, Kalat, Chenaran, and altitude of Mashhad), Yazd (LakhehMehriz mountain), Fars (ToodjEstahban Mountain), Markazi (Black Mountain) and the Kerman (Barez mountain).

The seeds were planted in the separate plots in Torogh station. Soil analyses were done within the plough horizon (0 to 30 cm) (Table. 1).

Table 1. Chemical soil analysis

Fe(ppm)	Mn(ppm)	K(ppm)	P(ppm)	N(%)	pH	EC(dS/m)	Soil depth(cm)	Soil-texture
3.76	5.40	219	10	0.092	8	1.62	30	Clay loam

Mashhad plain climate data

Annual mean temperature was 14-16 °C. Average minimum and maximum temperatures were 7.1 °C and 21.1 °C respectively. Annual precipitation ranges from 250 mm to 280 mm with concentration in spring and autumn. Total sunshine for Mashhad plain was 2892.4 h(Neamatollahi *et al.* 2012).

Planting date was done in the end of September and late 10 October. Experimental was laid in a randomized block design with three replications. Each line was grown in two rows of 3 m length, spaced at 50 cm, keeping plant to plant distance of 10 cm. The recommended packages of practices as intercultural practices were followed to raise a healthy crop. During the third year of experiment, 5 plants were randomly selected from each accession in each plot and tagged for recording the observations on the following traits viz., plant height, plant seed weight, number of seed umblet^{-1}, umblet plant^{-1}, total plant weight, number of umbel^{-1}, umblet umbel $^{-1}$, number of main branch, 1000-seed weight (g), seed yield (g m^{-2}), bio yield (g m^{-2}), essential oil (%), yield of essential oil (g m^{-2}) and harvest index. Standard statistical procedure were used for the analysis of variance, genotypic and phenotypic coefficients of variation (Burton 1952), heritability (Hanson *et al.* 1956) and genetic advance (Johnson *et al.* 1955).Heritability in broad sense (H 2 or h 2) was estimated according to Falconer (1989) using eq. 1:

Equation (1): $h^2 = \frac{\sigma^2}{\sigma^2 ph}$

h^2: Heritability; σ^2 g: genotypic variance and σ^2_{ph}: phenotypic variance. Genotypic (σ^2_g) and Phenotypic variances (σ^2_{ph}) were obtained from the analysis of variance table according to equations 2 and 3:

Equation (2):GCV(%)= $\frac{\sqrt{\sigma 2g}}{x} \times 100$

Equation (3):PCV(%)= $\frac{\sqrt{\sigma 2ph}}{x} \times 100$

Where:
σ^2_g = genotypic variance.

σ^2_{ph} = phenotypic variance.
X = sample mean.
Genetic advance (GA) was calculated with the method suggested by Allard (1960) using eq. 4:

Equation (4): $GA = K \times \sigma_{ph} \times h^2$

Where
GA: genetic advance.
K: constant = 2.06 at 5% selection intensity.
σ_{ph} : square root of phenotypic variance .
h^2 : Heritability.

The direct and indirect effects of each trait were assessed by path analysis using the method of Dewey and Lu (1959). Path analysis was performed using genotypic correlation considering essential oil yield as the response variable and grain yield per plant, grain weight per plant and oil percentage were used as dependent variables in the path analysis. When the objective is to establish relationships among the variables that affect grain yield or essential oil, path coefficient analysis is a more efficient method than the correlation analysis (Dewey & Lu 1959). The computer software system of SAS (Institute. 2002) and IBM SPSS statistics v22 Aoms were used for analysis of data for path analysis.

3. Results and Discussion

The analysis of variance (Table 2) showed significant differences for all the characters studied thereby provides an opportunity for selecting suitable genotypes with better performance for the traits. This further indicated that the genotypes selected in the present study were exhibiting considerable variation for almost all the traits. Similar results were also reported by Dar *et al*. (2011) and Devi (2004)who also reported high amount of variability between the collections. Improvement through breeding programme in any crop is dependent on the availability of information on genetic variability. The observed variability in crop plants is normally due to the variation in qualitative and quantitative heritability fractions influenced considerably by prevailing environmental condition. It is, therefore, desirable to study the nature of exhibited variability and to exploit same in the crop improvement programmes.

Variability in the population, especially in respect to the characters for which improvement is sought, is a prerequisite for successful selection. The estimates of phenotypic coefficient of variation (PCV) in general, were higher than the estimates of genotypic coefficient of variation (GCV) for all the characters (Table 3), indicating that all the characters had interacted with the environment. This suggested that apparent variation in all these characters is not only due to genotype but also due to the influence of environment and selection for such traits may not be reliable. These results are in close agreement with the earlier reports of Dar *et al*., (2011) and Azimzadeh*et al*., (2012). The estimates of genotypic coefficient of variation ranged from 0.02-1.75. The value was highest for plant biomass (g) (1.75) which was followed by bio yield (g m^{-2}) (0.52), seed yield (g m^{-2}) (0.47), seed (g.$plant^{-1}$)(0.45) and essential oil yield (g m^{-2}) (0.39). This is indicative of less amenability of these traits to environmental fluctuations and hence, greater emphasis should be given to these characters, while breeding cultivars from the present material. The lowest genotypic coefficient of variance was recorded in number of main branch (0.027) followed by plant height (0.13),1000-seed weight (g) (0.13), umblet $umbel^{-1}$ (0.14) and essential oil (%) (0.17). the low GCV suggests that the breeders should go for source of high variability for improvement in these traits. For rest of the characters the genotypic coefficient of variation (GCV) was found moderate. Dar *et al.* (2011) also noticed the moderate genotypic coefficient of variation for such traits and suggested that these traits can be improved by the vigorous selection. The estimates of phenotypic coefficient of variation (PCV) also followed the similar trend. The magnitude of PCV ranged from 0.08 for number of main branch to 2.09 for yield of essential oil. The characters with high phenotypic coefficient of variation indicated more influence of environmental factors. Therefore, caution has to be exercised during the selection program because the environmental variations are unpredictable in nature and may mislead the results. In the earlier studies also, Devi (2004), Majeed and Sharma (2006), Dar *et al*., (2011) and Azimzadeh*et al*., (2012) observed high genotypic and phenotypic coefficient of variation for the above studied traits.Duncan'smultiple-range test confirmed that results at L5that the genotype Khajeh forest was significantly superior with regard to number of seed $umblet^{-1}$, seed yield, bio yield and yield of essential oil (Table 4).

The coefficient of variability does not give any idea regarding the heritable portion of the variability; it can be ascertained by working out the heritability estimates. Heritability in narrow sense is the ratio of additive genotypic variance to the total variance and in broad sense it is the ratio of genotypic variance to the phenotypic variance (Lush 1949). In the present study heritability in broad sense is estimated. Encouraging results were obtained with respect to the heritability of the characters studied here. It could be observed from Table 3 that heritability estimates ranged from 0.53 to 0.96. The highest heritability was 0.96 for bio yield (g m^{-2}) and the rest for the number of umbel per plant, number of seed per umblet, plant weight (g), seed yield (g m^{-2}), plant height (cm), 1000-seed weight and finally essential yield (g m^{-2}) which suggested that the characters are least influenced by the environmental factors and also indicates the dependency of phenotypic expression which reflects the genotypic ability of cultivars to transmit the genes to their off-springs. High heritability estimates for various characters have also been reported by Puschmann et al. (1992), Pank and Quilitzsch(1996) in caraway (*Carumcarvi*), Kapila et al. (1997), Dar et al., (2011) and Azimzadeh et al., (2012) in Black Caraway (*Buniumpersicum*). The lowest value of heritability was recorded for stem branches and harvest index (0.53-0.58) which indicate the characters are highly influenced by environmental effects and genetic improvement through selection will be difficult. For rest of the characters, the estimates of heritability were found moderate. Characters with moderate heritability indicated that they are not dependable as their genotypic expression is superimposed by the environmental influences (Allard 1960). Thus the degree of success through selection depends also upon magnitude of heritability values. Furthermore, selection is also directly proportional to the amount of genetic advance.

Through the heritability estimates indicate the efficiency of selection system.Yet their scope is restricted as they are prone to change with environment, material used, etc. hence, more reliable information can be had from heritability estimates coupled with genetic advance rather than heritability alone in framing the selection procedure (Johnson *et al.* 1955). The genetic advance expressed as percentage of mean ranged from as low as 3.80 for number of main branches (plant-1) to as high as 244.65 for plant biomass (g).

According to stepwise multiple regression analysis of different traits, just a few characters were entered into the regression model (Table 5). Essential oil yield as dependent variable and the traits grain yield per plant, grain weight per plant and oil percentage were used as dependent variables in the path analysis. The direct and indirect effects of each of these variables and the dependent variable was determined by path analysis (Table 6).

As in the results table (6) is shown the number of seeds per plant has the highest direct effect on the yield of essential oil. The results of correlation were also observed that this variable has a significantly positive correlation (0.697**) with the essential oil yield.

Table 2.
Analysis of variance for 14 characters in Black Caraway

Source of variation	df	Plant height	Plant seed weight	Total plant weight	No.seed plant^{-1}	No.Umbel plant^{-1}	No.Seed umblet plant^{-1}	No.umblet umbel^{-1}	Stem branches
Replications	2	47.93	4.25	57.24	429748	12.61	4.21	0.80	0.012
Treatments	12	186.77**	52.53**	443.31**	11971394**	50.75**	50.25**	11.10**	0.016*
Error	24	25.82	3.60	17.61	75088	9.29	3.5	0.53	0.006
Total	38	77.81	19.09	154.13	4277299	22.56	18.30	3.88	0.010

1000- seed weight (g)	Bio- yield (g.m^{-2})	Seed yield (g.m^{-2})	Essential oil %	Essential yield (g.m^{-2})	Harvest index
0.10	911.15	5454	34.10	4.17	0.001
0.25*	7411.06**	634.15**	3.71*	1.14**	0.004^{ns}
0.09	272.86	31.68	1.50	0.18	0.002
0.14	2560.60	233.13	3.91	0.69	0.002

Table 3. Estimate of mean, components of variance, heritability (bs) and expected genetic advance in respect of 14 characters' inblack caraway

Trait	Range	Mean	Coefficient of variation		Heritability (bs) %	Genetic advance	Genetic advance as %age of Mean
			GCV	PCV			
Plant height	35-74	53.34	13.24	14.26	0.86	10.25	18.53
Plant seed weight	3.1-19.7	8.81	45.82	47.47	0.93	5.65	64.14
Number of seed umblet^{-1}	10-27.9	16.56	23.82	24.71	0.93	5.52	33.35
Umblet plant^{-1}	10-18	13.46	20.77	22.98	0.95	5.20	29.08
Total Plant weight	6.47-57.36	23.12	25.08	6.39	0.92	8.90	42.86
Number of umbels	11-31	17.9	20.77	22.98	0.82	5.20	29.08
Umblet umbel^{-1}	10-18	13.5	13.95	14.29	0.95	2.63	19.53
No. main branch	2-2.33	2.04	2.72	3.58	0.58	0.08	3.81
1000-seed weight(g)	1.52-2.88	2.10	10.42	13.19	0.62	0.32	14.59
Seed yield (g m^{-2})	11-68	30.15	47.00	48.22	0.95	19.84	65.80
Bio yield (g m^{-2})	27.36-229.45	93.85	51.98	52.96	0.96	68.29	72.77
Essential oil (%)	2.50-8	4.90	17.52	22.71	0.60	1.20	24.53
Yield of essential oil (g m^{-2})	0.28-7.48	1.76	39.28	42.81	0.84	0.79	55.00
Harvest index	0.23-0.44	0.33	7.95	10.95	0.53	0.04	11.13

Table 4. Comparison of different traits measured in 13 selected genotypes *Buniumpersicum* L. using Duncan's multiple range tests at 5% level.

Genotypes	Plant height (cm)	Plant seed weight	No.seed umblet-^{1}	No,Seed plant^{-1}	No.umbel	Bio yield (g m^{-2})
Qazvin	62.75 abc	8.09 def	17.13 cd	4107 bc	23.01 ab	88.91 def
Khajeh	66.33 ab	17.23 a	21.33 ab	7730 a	27.33 a	224.39 a
Chelmir	68.35 a	15.53 ab	22.75 a	7831 a	20.67 bc	150.72 ab
Ferezi	54.73 cde	7.50 ef	12.33 ef	3030 cd	18.87 bcd	75.24 ef
Khaf	45.33 e	11.37 cd	19.68 abc	5178 b	18.75 bcd	105.67 cd
Damghan	54.30 cde	3.43 g	10.67 f	1813 d	16.77 cd	31.47 g
Rafsanjan	55.00 cde	12.67 bc	18.67 bc	5239 b	19.60 bc	117.37 bc
Arak	47.67 de	5.77 efg	14.00 def	2541 cd	13.33 d	76.82 efg
Shirvan	63.64 abc	6.00 efg	14.10 def	3329 cd	15.78 cd	72.44 efg
Ferdows	48.59 de	7.20 ef	13.33 ef	3089 cd	16.53 cd	78.87 ef
Kerman	49.67 de	4.83 fg	14.01 def	2139 d	13.71 d	42.95 fg
Genu	45.80 e	6.40 efg	14.46 de	2560 cd	13.33 d	64.84 efg
Mashhad	57.27 bcd	8.57 de	22.80 a	5413 b	14.95 cd	90.41 de
LSD (p<0.05)	8.56	3.20	3.15	1460.25	5.14	27.83
SE	2.93	1.10	1.08	500.29	1.76	9.5

- Continuous Table 4

Genotypes	Seed yield (g m^{-2})	1000-seed weight (g)	Essential oil (%)	Yield of essential oil (g m^{-2})	Harvest index	Total Plant weight	No.main branches	Umblet umbel^{-1}
Qazvin	28.00 cd	1.96 abcd		0.51 bc	0.31 abcd	21.82 cde	2 b	10.61 e
Khajeh	61.67 a	2.21 abc		0.78 ab	0.27 cd	54.46 a	2 b	13.27 d
Chelmir	52.67 a	1.97 abcd		0.99 ab	0.35 abc	37.50 b	2 b	16.67 a
Ferezi	26.00 d	2.51 a		1.00 cde	0.35 abcd	18.27 e	2.2 a	12.98 d
Khaf	37.33 bc	2.13 abcd		1.00 a	0.36 ab	26.42 cd	2 b	14.32 bcd
Damghan	12.00 f	1.87 bcd		1.21 e	0.38 a	7.61 f	2.18 a	10.09 e
Rafsanjan	41.67 b	2.41 ab		1.40 bc	0.36 ab	29.29 c	2 b	14.33 bcd
Arak	20.33 def	2.17 abc		1.58 cd	0.26 d	18.99 de	2.1 ab	13.64 d
Shirvan	21.33 def	1.75 cd		1.62 cde	0.30 bcd	18.11 e	2 b	15.00 bc
Ferdows	24.67 de	2.31 abc		1.64 bcd	0.31 abcd	19.51 de	2 b	14.00 cd
Kerman	15.00 ef	2.00 abcd		2.22 de	0.35 abc	10.51 f	2 b	11.13 e
Genu	22.00 def	2.47 a		2.37 cde	0.34 abcd	15.72 ef	2 b	13.33 d
Mashhad	29.33 cd	1.55 d		2.47 cde	0.32 abcd	22.40 cde	2 b	15.64 ab
LSD ($p<0.05$)	9.48	0.51	2.06	0.71	0.072	7,07	0.065	1.23
SE	3.25	0.17	0.71	0.24	0.025	2.42	0.05	0.42

Table 5. Summary of stepwise multiple regression analysis of different traits of *Buniumpersicum* genotypes

Traits	R^2	$R^2_{partial}$	F
Seed per plant	0.485	0.485	34.91**
Essential oil	0.938	0.452	261.22**
Total plant weight	0.943	0.005	3.37^{ns}
Biological yield	0.949	0.006	3.99*

After the number of seeds per plant, essential oil percentage and seed weight per plant had a direct effect on grain yield essential oils, this result is entirely consistent with the results of stepwise regression (Table 6). Biological yield by weight of seeds per plant showed the highest positive indirect impact on essential oil yield. Grain weight per plant and the total weight of each plant has a very slight negative indirect effects to essential oil yield of grain through the essential oil percentage.

In general, the expected genetic advance as per cent of mean for majority of traits was high, which indicates that traits are governed by additive genes and selection will be rewarding for improvement of each trait. High heritability coupled with high genetic advance was observed for bio yield (g m^{-2}) and seed yield (g m^{-2}) thereby showing additive gene effect. Characters showing high heritability with high genetic advance may be due to additive gene action (Panse 1957) and thus, could be improved upon by adapting selection without progeny testing. High heritability accompanied with low genetic advance were recorded for plant seed weight(g), number seed per umblet, number umblet plant, total plant weight, number of umbels, plant seed weight, umblet per umbel and essential oil (%), yield of essential oil (g m^{-2}) and harvest index which indicates the presence of non-additive type of gene action. Panse(1957) reported that high heritability correlated with low genetic advance indicates non-additive gene effects. The high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for such traits may not be rewarding. For rest of the characters the heritability accompanied with genetic advance were found moderate. The above results are in similarity with the findings of Majeed and Sharma (2006), Dar *et al*., (2011) and Azimzadeh*et al*., (2012).

The comparison of various morphological traits using Duncan's multiple range tests revealed significant variation among the 13 ecotypes *of Buniumpersicum* (Table 4). The genotype Chelmir was the tallest plant (68.35 cm) and was significantly superior to other genotypes, while the genotypes Geno mountain was significantly inferior with regard to the plant height.

Khajehforest recorded significantly highest plant seed weight, while the lowest seed weight was recorded in Damghan. The genotype Mashhad accession had the highest number of seed umblet^{-1} (22.80). Chelmir and Khajeh forest was superior then other accessions for the purpose of essential oil yield although other genotypes were found with more percentages of essential oil.

Genetic variation and path coefficient analysis was also studied in seven genotypes of *Buniumpersicum* in India. The results were almost the same and the values of genotypic correlation coefficients were higher in general, than the phenotypic ones. Number of seed umbellet^{-1}, number of seed plant^{-1}, number of umbellets umbel^{-1} and number of seed umbel^{-1} recorded significant positive association with seed yield ha^{-1} at the genotypic level. However, at phenotypic level, number of primary branches plant^{-1}, number of umbellets umbel^{-1}, number of umbels plant^{-1}, number of seed umbellet^{-1}, number of seed umbel^{-1}, number of seed plant^{-1} and 1000 seed weight were strongly associated with seed yield ha^{-1}. According to the residual effects, which was significantly low (0.055) indicating that the number of primary branches plant^{-1} was the most reliable trait for improving the seed yield of *Buniumpersicum* through selection(Gupta *et al.* 2013).

The seed weight per plant traits and the total weight of each plant had the highest positive direct effect on yield and essential oil percentage had the highest negative direct effect on essential oil yield. High heritability accompanied by high genetic advance was observed for number of seed umblet^{-1}, umblet plant^{-1}, total plant weight, number of umbel^{-1} and bio yield. Therefore, it is concluded that these traits had to be accounted for direct selection for the improvement of yield. From this point, the genotype Khajeh forest was significantly superior with regard to number of seed umblet^{-1}, seed yield, bio yield and as well for the yield of essential oil.

Table 6.

Path coefficient analysis showing direct (diagonal) and indirect (non-diagonal) effect of four chosen characters based of the result of stepwise multiple regression analysis on the yield of essential oil.

Traits	direct / indirect effect	Seed weight/plant	Plant weight	Essential percentage
Plant weight	direct	0.926	0	0
	indirect	0	0	0
Essential percentage	direct	-0.079	0	0
	indirect	-0.020	-0.022	0
Essential oil yield	direct	0.582	0.196	0.676
	indirect	0.114	-0.015	0
	Residual effect: 0.226			

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