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Research Paper

Flowering and pollen behavior of some olive cultivars grown in mid hills of Jammu and Kashmir

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ABSTRACT

Sixteen cultivars of olive having age of twenty years with uniform growth and vigour were examined for their flowering and pollen characters. The experiment was carried out in the orchard of state Department of Horticulture at Govindpura, district Ramban (J & K). Observations were recorded on flowering (date of first flower opening, date of full bloom, date of end of bloom, duration of flowering, inflorescence length and width, number of flowers per panicle, hermaphrodite and staminate flowers and their ratio) and pollen (pollen morphology, pollen viability and pollen germination) characters. Among the cultivars studied, earliest flowering (14th April) was observed in cultivars Nocellara Etnea, Frantoio and Cipressino, while late flowering was recorded in cultivar Nocellara Messinese i.e. 20th April. Maximum duration of flowering was observed in cultivar Moraiolo (15 days) while cultivars Cerignola, Itrana, Leccino, Nocellara del Belice, Nocellara Messinese and Ottobratica flowered for less number of days (12.00 days). Maximum number of flowers/panicle was observed in cultivar Cipressino (23.88) which also had maximum hermaphrodite/staminate ratio (4.48). Minimum number of flowers/panicle was observed in cultivar Carolea (13.62) and cultivar Nocellara del Belice registered minimum values for hermaphrodite/ staminate ratio (1.48). Cultivar Itrana (96.09 %) had highest pollen viability while cultivar Frantoio (83.04 %) had least viable pollens. Maximum pollen germination was recorded in cultivar Nocellara del Belice (38.50 %) and minimum in cultivar Moraiolo (24.73 %). A wide variation was observed with respect to flowering and pollen characters among the different olive cultivars.

Key words: Flowering, hermaphrodite, Olive, pollen, staminate

Olive (*Olea europea* L.) is a hardy, dicotyledonous evergreen fruit tree which is cultivated in the Mediterranean countries since time immemorial. It is known as the 'tree of liquid gold' because of the great importance of its oil. The juvenile period of olive trees is long and varies considerably among seedling populations and comes into bearing at the age of about 10 year (Acebedo *et al*. 1997). The annual world production of olive fruits is approximately 23.64 million tonnes from an area of 12.76 million ha with total annual olive oil production of about 3.26 million tonnes (FAO 2020). In Asia, olive is confined to Iraq, Iran, China and India. In India, there is a tremendous scope for olive cultivation in the Himalayan mountainous regions which includes Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Olive trees produce two different types of creamy white flowers, a perfect flower, which contains both male and female parts, and a staminate flower with stamens only. The proportion of perfect and staminate flowers in olive varieties is genetically determined but also depends on climatic conditions and the level of fruit production in the previous year (Lavee *et al.* 2002). Therefore, it may vary from year to year, tree to tree, shoot to shoot and inflorescence to inflorescence (Martin and Sibbett 2005). During 1984-1987 under Indo-Italian Fruit Development Programme some promising olive varieties were introduced in Jammu and Kashmir. Till date the flowering behavior of those varieties was not studied and the flowering behavior of any fruit crop has direct relevance on the fruiting behavior and yield. As olive trees

though produces an enormous number of flowers but the proportion of complete or perfect flowers determines the final yield. Keeping in view the above facts, present study on the flowering behavior was conducted on diverse germplasm of olive which will be helpful in formulating the crossing programme among different cultivars.

MATERIALS AND METHODS

Present investigation was carried out at the Advance Centre for Horticulture Development, Govindpura, Ramban (Jammu and Kashmir) during the years 2014 and 2015 to study the flowering behavior and pollen studies of Sixteen olive cultivars with twenty years of age. Observations were recorded on various flowering characters viz. date of first flower opening, date of full bloom, date of end of bloom and duration of flowering. Inflorescence length and width were measured with the help of Vernier caliper. Number of flowers/panicle, hermaphrodite flowers, staminate flowers and their ratio were also determined. Fresh pollen was collected by dehiscing the anthers in petri dish and pollen morphology was studied. Pollen viability was observed in one per cent acetocarmine solution as suggested by Hechmi *et al.* 2015 while pollen germination was determined through conducting *in-vitro* germination by culturing the pollen grains under 10 per cent sucrose solution as described by (Hechmi *et al.* 2015). The data generated from these investigations were pooled and analyzed by applying Randomized Block Design. The level of significance was tested for different variables at 5 per cent (Panse and Sukhatme 1989). Data were analysed using analysis of variance OPSTAT.

RESULTS AND DISCUSSION

All the cultivars under study showed large variation with respect to their flowering behavior (Fig. 1). During first year of study, flower blooming started from 14th April in cultivars Cipressino, Frantoio and Nocellara Etnea followed by cultivars Coratina, Leccino and Moraiolo i.e. on 15th April, however in the second year early flowering was observed in cultivar Nocellara Etnea (17th April) followed by cultivars Frantoio (18th April), Moraiolo (18th April) and Cipressino (19th April). Late flowering during 1st and 2nd year was observed in cultivar Nocellara Messinese i.e. 20th April and 24th April, respectively. Full bloom in studied cultivars ranged from 20th April to 26th April in the first year and from 25th April to 30th April in the second year of study. End of flowering in the first year was early in cultivar Frantoio (25th April), however it was late in cultivars Brancolilla, Carolea, Cerignola, Cornicobra Attica and Nocellara Messinese (1st May).

In the second year of study cultivar Frantoio registered early end of flowering i.e. on 29th April whereas cultivar Nocellara Messinese retained flowers up to 5th May. Flowering duration among the studied cultivars ranged from 12 days (Cerignola, Itrana, Leccino, Nocellara del Belice, Nocellara Messinese and Ottobratica) to 15 days (Moraiolo) (Table 1). Variations in flowering time, full bloom and flowering duration have also been reported in different cultivars of olive (War, 2004; Ulas and Gezerel, 2009; Abo-El-Ez and Hassnain, 2009).

Inflorescence length, width and number of flowers per panicle showed a considerable variation in cultivars under study (Table 1). Maximum inflorescence length was recorded in cultivar Cipressino (2.83 cm) which was statistically higher among all the varieties and followed by cultivar Cerignola (2.64 cm) whereas minimum length of inflorescence was measured in cultivar Carolea (1.93 cm). Cultivar Nocellara Etnea (1.37 cm) registered maximum inflorescence width which was statistically at par with cultivar Nocellara Messinese (1.34 cm) however minimum inflorescence width was measure in Cornicobra Attica (1.02 cm).

In earlier reports also mean length of inflorescence ranged from 2.23 cm to 4.13 cm (Ferrara *et al.* 2002) and 18.68 mm to 33.63 mm (Ulas and Gezerel 2008). The relative proportion of perfect and staminate flowers varied greatly among inflorescence on the same branch as well as within branches, trees, cultivars and season. The development of imperfect flowers had also been shown to be influenced by season of bloom, available soil moisture, nutrition and leaf to bud ratio (Cuevas and Polito 2004).

Maximum number of panicle per flower was recorded in cultivar Cipressino (23.28) which was statistically higher among all the cultivars and followed by cultivar Frantoio (20.82), whereas minimum number of panicles per flower were observed in cultivar Carolea (14.06) (Table 1). The mean genetic constitution of variety affects the flower load. Number of flowers per panicle reported in earlier studies varied from 13.7 to 19.9 (War, 2004) and 13.0 to 31.3 (Palasciano *et al*., 2008).

Olive blooms profusely, but some of the flowers may be imperfect i.e. staminate flowers. Percentage of hermaphrodite and staminate flowers varied from cultivar to cultivar in the present study (Table 2). Cultivar Cipressino had maximum (78.66 %) and minimum (21.33 %) hermaphrodite and staminate flowers, respectively, however, number of hermaphrodite flowers in cultivar Cipressino were statistically at par with Frantoio (77.99 %), Leccino (77.83 %) and Coratina (76.66 %). Nocellara del Belice had maximum (36.99 %) and minimum (62.99 %) percentage of staminate and hermaphrodite flowers, respectively.

Table 1: Duration of flowering, inflorescence size and number of flower/panicle of different olive cultivars (Pooled data)

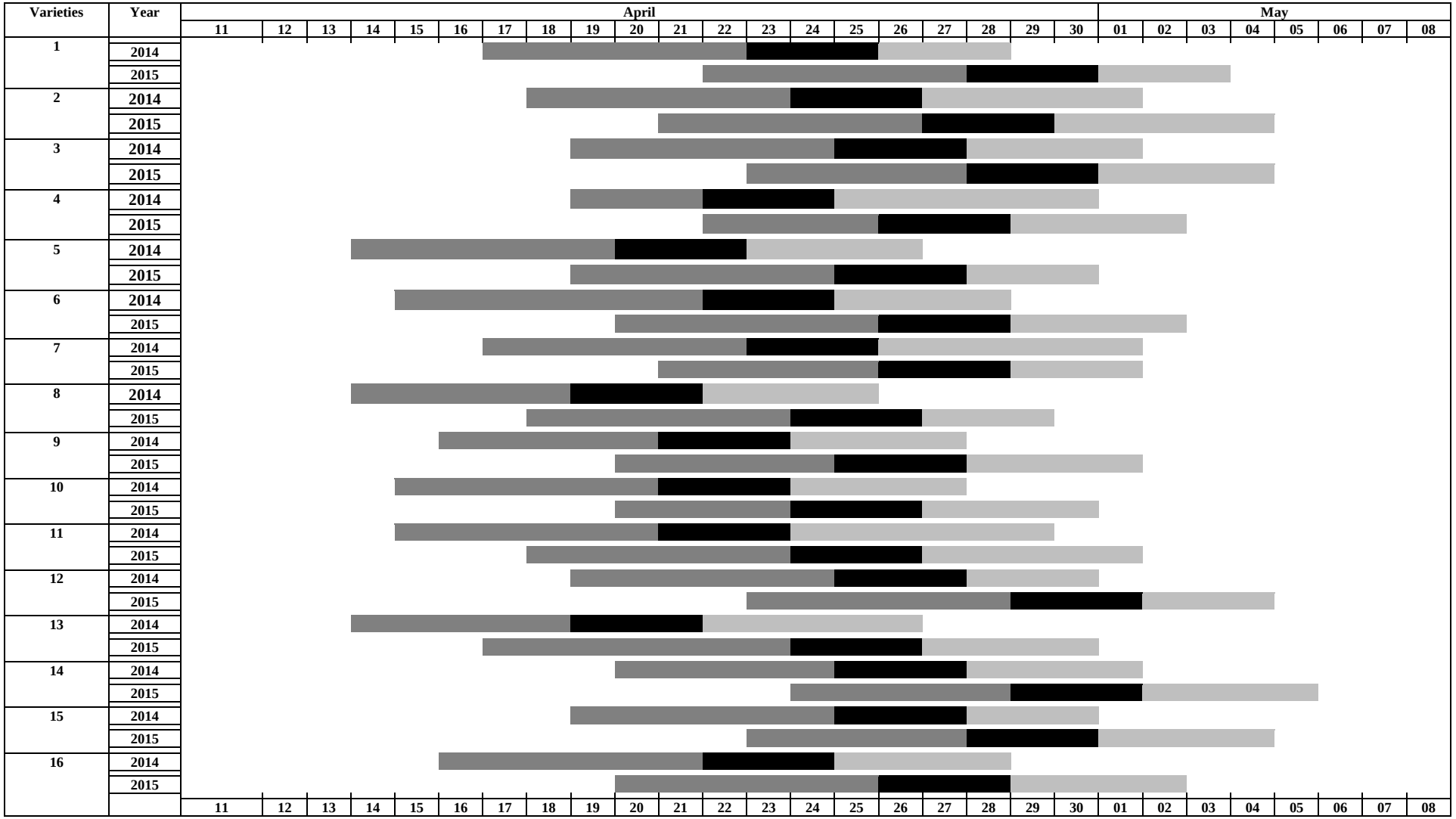
Varieties	Duration of flowering	Inflorescence length (cm)	Inflorescence width (cm)	Number of flower/panicle
Azapa	13.0	2.26	1.16	17.20
Brancolilla	13.0	2.05	1.17	16.42
Carolea	13.0	1.93	1.04	14.06
Cerignola	12.0	2.64	1.27	17.10
Cipressino	13.0	2.83	1.23	23.28
Coratina	14.0	2.44	1.16	18.17
Cornicobra Attica	14.0	2.05	1.02	15.07
Frantoio	13.0	2.45	1.29	20.82
Itrana	12.0	2.31	1.25	15.11
Leccino	12.0	2.28	1.17	18.23
Moraiolo	15.0	2.42	1.20	17.87
Nocellara del Belice	12.0	2.23	1.19	15.21
Nocellara Etnea	14.0	2.24	1.37	14.35
Nocellara Messinese	12.0	2.19	1.34	14.63
Ottobratica	12.0	2.37	1.18	17.38
Tonda Iblea	13.0	2.22	1.03	16.89
$CD_{0.05}$	**0.90**	**0.10**	**0.06**	**1.37**

Similar proportion of hermaphrodite and staminate flowers in different olive cultivars were also reported by Wu *et al*. (2002), War (2004) and Abo-El-Ez and Hassman (2009). Kumar (1998) also reported that the proportion of hermaphrodite flowers was higher as compared to staminate flowers in the different olive cultivars.

Table 2: Hermaphrodite and staminate flowers and pollen size of different olive cultivars (Pooled data)

Varieties	Hermaphrodite flowers (%)	Staminate flowers (%)	Pollen length (µm)	Pollen breadth (µm)
Azapa	73.99	25.99	23.01	20.94
Brancolilla	73.66	26.33	21.47	20.68
Carolea	68.33	31.66	22.13	20.32
Cerignola	72.83	27.16	22.62	20.43
Cipressino	78.66	21.33	22.57	19.81
Coratina	76.66	23.33	21.02	19.09
Cornicobra Attica	70.16	29.83	23.53	21.73
Frantoio	77.99	21.99	23.71	22.16
Itrana	65.83	34.16	24.05	21.06
Leccino	77.83	22.16	24.98	22.37
Moraiolo	74.16	25.83	21.41	19.00
Nocellara del Belice	62.99	36.99	24.79	21.51
Nocellara Etnea	63.66	36.33	24.99	22.11
Nocellara Messinese	66.66	33.33	23.97	21.42
Ottobratica	73.99	25.99	23.05	20.91
Tonda Iblea	71.49	28.48	23.22	21.01
$CD_{0.05}$	**2.19**	**2.17**	**0.64**	**0.41**

Fig. 1: Graphically presentation of flowering time and duration of different olive cultivars



Data presented in Fig 2 depicts that during the first year of study, maximum hermaphrodite/staminate flowers ratio was recorded in cultivar Frantoio (3.69) which was statistically at par with cultivar Leccino (3.42) whereas minimum hermaphrodite/ staminate flowers ratio was recorded in cultivar Nocellara del belice (1.48). Maximum and minimum hermaphrodite/ staminate ratio in the second year of study was recorded in Coratina (3.69) and Nocellara Etnea (1.94) however Coratina was statistically at par with Frantoio (3.62) and Leccino (3.62). Hermaphrodite/ staminate ratio in the earlier studies ranged from 1:0.26 to 1:0.95 (War 2004). The highest sex ratio indicates that such cultivars could not produce sufficient number of perfect flowers which actually contribute to fruit yield. Lavee *et al*. (1996) stated that the ratio between hermaphrodite and staminate flowers varied considerably from year to year, both due to developmental and fruiting history of the tree and specific environmental conditions.

Highest pollen length was recorded in cultivar Nocellara Etnea (24.99 µm) closely followed and statistically at par with cultivars Leccino (24.98 µm) and Nocellara del Belice (24.79 µm) whereas maximum pollen breadth was registered in cultivar Leccino (22.37 µm) which was statistically at par with cultivars Frantoio (22.16 µm) and Nocellara del Belice (22.11 µm) (Table 2). Minimum pollen length and pollen breadth was measured in cultivar Coratina (21.02 µm) and cultivar Moraiolo (19.00 µm), respectively. Javady and Arzani (2001) also observed variable pollen length and breadth in different olive cultivars. The size of pollen grains was affected by genetic constitution of varieties. L/D ratio of pollen in the first year of study ranged between 1.02 (Brancollila) and 1.17 (Nocellara del Belice) whereas in the second year, L/D ratio ranged from 1.05 (Brancollila and Frantoio) to 1.14 (Itrana) (Fig 2).

Pollen viability was highest in cultivar Leccino (96.09 % and 92.48 %) (Table 3) however in the first year of study cultivar Leccino was at par with cultivars Nocellara Messinese (95.41 %), Nocellara Etnea (94.64 %) and Nocellara del Belice (94.12 %), however in the second year, cultivar Leccino was statistically at par with cultivars Carolea (92.42 %) and Nocellara Messinese (91.56 %). Minimum pollen viability was recorded in cultivar Frantoio (83.04 %) in the first year and in cultivar Moraiolo (85.66 %) in the second year of study. Earlier reports conducted on different olive cultivars recorded pollen viability ranges from 67.88 per cent to 87.97 per cent (War 2004) and 53.50 per cent to 90.70 per cent (Palasciano *et al.* 2008). Wu *et al.* (2002) reported that cultivar Frantoio had the highest pollen viability, Kalamata and Picual were intermediate and Manzanillo and Pendolino the lowest. Maximum and minimum pollen germination in the first year of study was recorded in cultivar Nocellara del Belice (38.50 %) and cultivar Moraiolo (24.73 %) although cultivar Nocellara del Belice was statistically at par with cultivar Leccino (36.43 %) however in the second year of study cultivar Nocellara Etnea (36.50 %) had maximum pollen germination which was statistically at par with cultivar Nocellara del Belice (34.62 %).

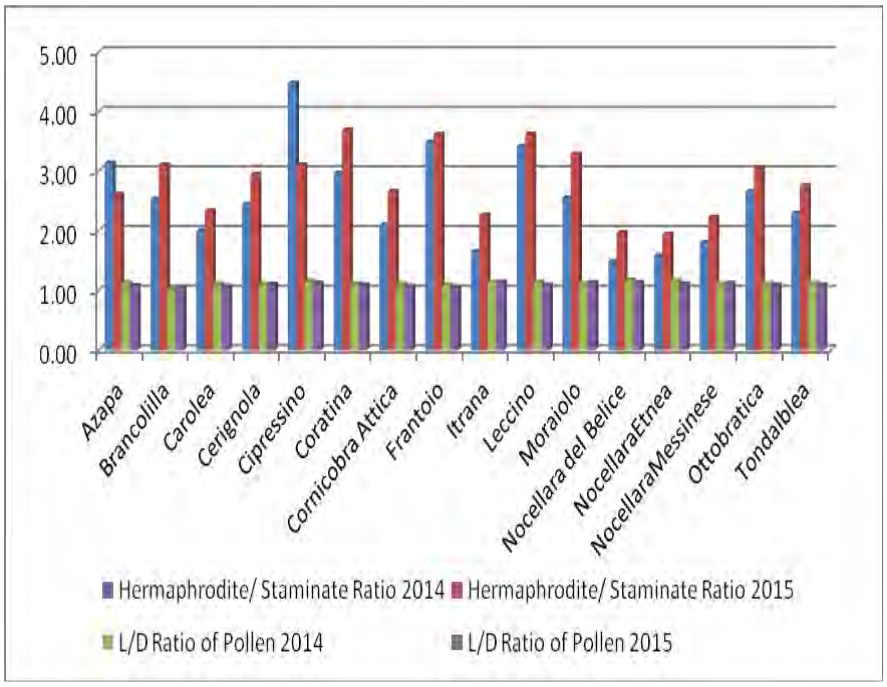


Fig. 2: Hermaphrodite/staminate flowers ratio and L/D ratio of pollen in different olive cultivars

However minimum pollen germination was recorded in cultivar Moraiolo (28.12 %). In earlier studies Ribeiro *et al.* (2012) also reported that the difference with regard to pollen viability and pollen germination appeared to be cultivar specific. Environmental conditions viz. relative humidity also affects viability of olive pollen (Pinney and Polito 1990).

Table 3: Pollen viability and pollen germination of different olive cultivars

Varieties	Pollen viability (%)		Pollen germination (%)	
	2014	2015	2014	2015
Azapa	91.40	90.76	31.92	30.48
Brancolilla	92.43	91.09	33.07	31.00
Carolea	91.51	92.42	29.39	32.24
Cerignola	92.67	90.72	30.43	30.90
Cipressino	85.67	89.14	31.45	32.56
Coratina	89.66	86.34	30.84	33.85
Cornicobra Attica	93.72	90.27	30.66	29.30
Frantoio	83.04	88.50	26.56	29.50
Itrana	84.24	87.74	26.50	30.25
Leccino	96.09	92.48	36.43	31.66
Moraiolo	86.43	85.66	24.73	28.12
Nocellara del Belice	94.12	90.58	38.50	34.62
NocellaraEtnea	94.64	91.12	35.06	36.50
NocellaraMessinese	95.41	91.56	35.89	32.60
Ottobratica	86.50	87.20	26.74	30.63
TondaIblea	84.48	86.22	27.84	33.40

From the above study it is clear that Leccino, Nocellara del Belice and Nocellara Etnea proved to be the best pollen source due to high pollen viability and pollen germination for all the studied cultivars under study as the blooming period of these cultivars synchronizes with the blooming period of almost all the cultivars under study, which is a prerequisite for effective pollination.

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