EFFECT OF GIRDLING AND PLANT GROWTH REGULATORS ON PRODUCTIVITY IN OLIVE *(OLEA EUROPAEA)*

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ABSTRACT:- Olive *(Olea europaea* L.*)* belongs to family oleaceae, is one of the most important fruit crop grown worldwide due to their nutritional and economic importance. Unfruitfulness in olive has frequently been observed which may be attributed to numerous factors. Some of them are probably related to the internal imbalance of growth regulators and other physiological factors. Plant growth regulating hormones like gibberellic acid (GA_3), salicylic acid (SA) and naphthalene acetic acid (NAA) alone and/ or coupled with girdling operations may improve cropping potential of existing olive varieties in Pakistan. Therefore, this study was envisaged on olive trees to explore possibilities of inducing fruitfulness through the use of hormones and girdling operations under Islamabad conditions. Treatments consisted of control, girdling and spray of gibberellic acid, salicylic acid and naphthalene acetic acid @ 30 ppm, 250 ppm and 60 ppm, respectively. This experiment was laid out according to Randomized Complete Block Design with two factors, in four replications. Statistical analysis of data showed that T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect on number of inflorescence, flower count, perfect flower percentage, fruit drop percentage, fruit set percentage, fruit harvest percentage, fruit size, fruit weight, pulp weight and oil contents followed by girdling, NAA and SA. All growth parameters were found enhanced in Uslu (V_1) with exception for fruit drop percentage, fruit size and fruit weight which was improved in Nochlerra (V_2).

Key Words: Olea europaea; Cultivation; Plant Hormones; Oil Contents; Yield Components; Pakistan.

INTRODUCTION

Pakistan is an agricultural country having a variety of climates and topography, which provides appropriate conditions for diversity of fruits. Olive *(Olea europaea* L.*)* of family oleaceae, is used for high quality edible oil extraction and pickling. Olive is native to the Mediterranean regions where it has been in cultivation since ancient times. It is mostly grown in Spain, Italy, Greece, Turkey, Syria, Morocco and USA (Griggs et al., 1975).

Olive cultivation can be successfully carried out in Pakistan, if relevant inputs, incentives and technologies are made available to the farming community.

Two kinds of flowers are produced in olive: a perfect flower containing both male and female parts, and a staminate flower with stamens only. There are self-incompatible varieties that do not set fruit without other varieties nearby, and there are varieties that are incompatible with certain others

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(Hartmann et al., 1980). Incompatibility can also occur for environmental reasons such as high temperatures (Bianchini and Corbetta, 1976; Klein, 1994). Fruit set is an important component of yield. Unfruitfulness in olive has frequently been observed which may be attributed to numerous factors. Some of them are probably related to the internal imbalance of growth regulators and other physiological factors. According to the nutritional diversion hypothesis (Sachs, 1977) certain endogenous hormones are involved in the regulation of fruit setting in many fruits. Plant growth regulating chemicals like gibberellins, salicylic acid and naphthalene acetic acid may be used to increase fruit set of certain fruit crops like tomatoes, apples, dates, citrus and several other herbaceous plants. It has been observed that GA_3 plays an important role in increasing fruit set and development of olive. Foliar application of GA_3 at blossom time promoted fruit set and yield in mandarin and moreover gibberellic acid maintained fruit peel quality on tree as well as in storage condition and reduced post-harvest decay (Almeida et al., 2004; EI-Otmani et al., 1990).

Gibberellins are known for their ability to increase cell enlargement (Arteca, 1996; Davis, 2004; Pharis and King, 1995), thus enhancing fruit growth in certain species such as citrus (Eman et al., 2007; El-Sese, 2005), litchi (Stern and Gazit, 2000; Chang and Lin, 2006), guava (El-Sharkawy and Mehaisen, 2005), and pear (Zhang et al., 2007). In all species so far studied, gibberellins had the potential for increasing fruit size. Salicylic acid is considered to be a potent plant hormone (Raskin, 1992) because of its diverse regulatory roles in plant metabolism (Popova et al., 1997). Salicylic acid is an endogenous plant growth regulator and its role is evident in seed germination and fruit yield (Klessig and Malamy, 1994).

To increase the fruit size normally the farmers practice hand thinning of fruit. But recently naphthalene acetic acid (NAA) has been reported to be useful for thinning of fruits (Agusti et al., 2000). It has important role in fruit formation, abscission cell elongation, apical dominance, photoperiod and geotropism (Haidry et al., 1997). Moreover, girdling was also observed useful to enhance the production potential of the girdled twig in olive (Badr et al., 1970). Girdling of olive trees improves the internal hormonal and carbohydrate level of the canopy. Girdling is an important practice responsible for improving fruit setting, yield as well as physical and chemical properties of fruits in various olive cultivars (Proietti and Tombesi, 1990; Petrisou and Voyiatzis, 1994).

Application of plant growth regulators like gibberellins, salicylic acid and naphthalene acetic acid alone or coupled with girdling operations may improve cropping potential of our existing olive cultivars. It was therefore, highly desirable to verify these treatments in different combinations with variable doses. This study was therefore, envisaged on olive trees to explore possibilities of inducing fruitfulness through the use of plant growth regulators (PGRs) and girdling operations.

MATERIALS AND METHOD

This study was carried out on olive cultivars Uslu (V_1) and Nochlerra (V_2) to explore possibilities of inducing fruitfulness through the use of PGRs and girdling operations under Islamabad conditions during 2010-11. Treatments consisted of control, girdling and spray of gibberellic acid, salicylic acid and naphthalene acetic acid @ 30 ppm, 250 ppm and 60 ppm, respectively. Plant growth regulating hormones were sprayed twice, in March and June while girdling was done once in March, 2010. Uniform branches (2-3 cm in diameter) of canopy were selected in all olive trees in the selected sites. For girdling, 2-3 mm wide bark at the base of the branch from all around was removed without injuring the wood with sharp knife.

This experiment was laid out according to Randomized Complete Block Design with two factors, in four replications. The data obtained in response to treatments was computed following ANOVA technique and DMR test was applied to differentiate the treatment differences (Steel et al., 1997) using Statistics Version 9 computer software package.

RESULTS AND DISCUSSION

Reproductive Growth

Number of Inflorescence

The results demonstrated that maximum number of inflorescence 291 was produced in Uslu (V_1) while minimum (89) was observed in Nochlerra (V_2) at T_2 and T_0 respectively (Table 1). However, response of both cultivars of olive was better with T_2 where Gibberellic acid (GA_3) was applied at concentration of 30 ppm. Furthermore, T_0 where no girdling and PGRs were applied resulted in least response for number of inflorescence production in both cultivars (Table 3). Overall performance of Uslu (V_1) was better as compared to Nochlerra (V_2).

Number of Perfect Flower

Results showed that maximum perfect flower (485) were produced in Uslu (V_1) while minimum (79) was observed in Nochlerra (V_2) at T_2 and T_0 respectively (Table 1). However, T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect for both cultivars of olive (Table 3). Furthermore, T_2 resulted in maximum (337) while T_0 minimum (97) perfect flower production.

Flower Drop

Results showed that maximum flower drop was 202 produced in Uslu (V_1) while minimum 60 was observed in Nochlerra (V_2) at T_1 and T_2, respectively (Table 1). However, T_2 where GA_3 was applied at concentration of 30 ppm caused more pronounced effect for flower drop in both cultivars of olive (Table 3). Furthermore, T_1 resulted in maximum (166) while with T_0 minimum (88) flower drop was observed. Overall, maximum flower drop (202) was recorded in Uslu (V_1)

Table 1. Effect of girdling and PGRs on vegetative and reproductive growth of olive

Treatment	No. of Inflore-scence		No. of perfect flower		Flower drop		Fruit set (%)		Fruit drop (%)		Fruit harvest (%)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0 (control)	166 e	89 i	115 g	79 i	108 e	69 g	6.06 c	12.87 ab	66.52 a	70.02a	33.5 d	29.9 d
T_1 (girdling)	194 c	186 d	237 b	150 e	202 b	129 d	14.6 ab	13.9 ab	31.5 d	63.9 ab	68.6 a	36.1 cd
T_2 (GA_3)	291 a	210 b	485 a	188 c	135 a	60 c	16.4 a	13.5 ab	37.4 cd	51.1 bc	62.6 ab	48.9 bc
T_3 (SA)	117 g	133 f	178 d	119 g	166 c	105 e	7.0 c	12.0 b	40.8 cd	64.2 ab	59.2 ab	35.8 cd
T_4 (NAA)	208 b	110 h	137 f	90 h	127 d	78 f	7.0 c	13.4 ab	31.6 d	60.1 ab	68.4 a	39.9 cd
Mean	195 A	146 B	230 A	125 B	147 A	92 B	10.2 B	13.1 A	41.56 B	61.88 A	58.44 A	38.12 B
LSD	6.18*		5.63*		5.14*		4.33*		14.62*		14.46*	

Means followed by same letters do not differ significantly at 5% level

Table 2. Effect of girdling and PGRs on fruit quality of olive

Treatment	Fruit size (cm)		Fruit weight (g)		Pulp weight (g)		Oil contents (%)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0 (Control)	1.45 g	1.81 e	1.53 i	1.86 g	1.15 f	1.08 g	11.3 f	10.7 f
T_1 (Girdling)	2.15 c	2.47 b	2.21 e	2.76 b	1.65 b	1.50 c	16.6 bc	15.9 c
T_2 (GA_3)	2.23 c	2.67 a	2.37 d	2.94 a	1.75 a	1.60 b	18.3 a	17.4 ab
T_3 (SA)	2.01 d	2.40 b	2.10 f	2.61 c	1.45 c	1.33 d	12.2 e	11.6 ef
T_4 (NAA)	1.66 f	2.00 d	1.70 h	2.08 f	1.36 d	1.25 e	14.4 d	13.8 d
Mean	1.90 B	2.27 A	1.98 B	2.45 A	1.47 A	1.35 B	14.6 A	13.9 B
LSD	0.092*		0.045*		0.03*		0.42*	

Means followed by same letters do not differ significantly at 5% level

Fruit Set Percentage

The results demonstrated that maximum (16.4 %) and minimum (6.06 %) fruit set percentage in Uslu (V_1) at T_2 and T_0, respectively (Table 1). However, in Nochlerra (V_2) maximum (13.9 %) and minimum (12.0 %) was found with T_1 and T_3, respectively. Nochlerra (V_2) showed better response as compared to Uslu (V_1). $T_1 \approx T_2$ and $T_3 \approx T_4 \approx T_0$ showed similar behavior in both cultivars for fruit set percentage (Table 3).

Fruit Drop Percentage

It was counted till harvesting of fruits. Results revealed that maximum fruit drop percentage was 70.02% in Nochlerra (V_2) while minimum 31.5% was observed in Uslu (V_1) at T_1 and T_4, respectively (Table 1). However, all treatments showed almost equal trend for fruit drop percentage except T_0. Moreover, T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect for fruit drop in both cultivars of olive (Table 3). Data showed that T_2 resulted in minimum (44.3%) fruit drop. Overall, maximum fruit drop percentage was 70.02% observed in Nochlerra (V_2).

Fruit Harvest Percentage

Results demonstrated that maximum fruit harvest percentage was 68.6% in Uslu (V_1) while minimum 29.9% was observed in Nochlerra (V_2) at T_1 and T_0 respectively (Table 1). However, all treatments showed almost equal trend for fruit harvest percentage (Table 3). Moreover, T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect for

Table 3. Mean differential effect of girdling and PGRs on vegetative and reproductive growth fruit quality of olive

Treatment	No. of Inflor.	No. of perfect flower	Flower drop	Fruit set (%)	Fruit drop (%)	Fruit harvest (%)	Fruit size (cm)	Fruit weight (g)	Pulp weight (g)	Oil contents (%)
T_0 (Control)	127 D	97 E	88 E	9.47 B	68.27 A	31.72 B	1.63 E	1.69 E	1.11 E	11.0 E
T_1 (Girdling)	190 B	194 B	166 A	14.2 A	47.7 B	52.4 A	2.31 B	2.49 B	1.58 B	16.2 B
T_2 (GA_3)	250 A	337 A	97 D	14.9 A	44.3 B	55.8 A	2.45 A	2.66 A	1.68 A	17.9 A
T_3 (SA)	125 D	149 C	136 B	9.5 B	52.5 B	47.5 A	2.21 C	2.36 C	1.39 C	11.9 D
T_4 (NAA)	159 C	114 D	103 C	10.2 B	45.9 B	54.2 A	1.83 D	1.89 D	1.31 D	14.1 C
LSD	4.37*	3.98*	3.64*	2.60*	10.22*	10.22*	0.06*	0.032*	0.04**	0.67**

Means followed by same letters do not differ significantly at 5% level

fruit harvest in both cultivars of olive. Data also showed that T_0 resulted in minimum (31.72%) fruit harvest (Table 3). Overall, maximum fruit harvest percentage was 55.8% found in Uslu (V_1) with treatment T_2.

Fruit Quality

Fruit Size (cm)

Fruit size of both cultivars of olive was greatly affected by all treatments. Results demonstrated that maximum fruit size was 2.67 cm in Nochlerra (V_2) while minimum (1.45 cm) was in Uslu (V_1) at T_2 and T_0 respectively (Table 2). However, all treatments performed differently for fruit size (Table 3). Data demonstrated that T_2 where GA_3 was applied at concentration of 30 ppm caused more pronounced effect for fruit size (2.45 cm) in both cultivars of olive (Table 3). Furthermore, T_0 resulted in minimum (1.63 cm) fruit size in both cultivars of olive. Overall, Nochlerra (V_2) performed better than that of Uslu (V_1) with all treatments.

Fruit Weight (g)

Data showed that maximum fruit weight was 2.94 g in Nochlerra (V_2) while minimum 1.53 g was in Uslu (V_1) at T_2 and T_0 respectively (Table 2). However, all treatments performed differently and showed significant difference for fruit weight (Table 3). Data demonstrated that T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect for fruit weight (2.66 g) in both cultivars of olive. Furthermore, T_0 resulted in minimum (1.69 g) fruit weight in both cultivars of olive. Overall, Nochlerra (V_2) performed better than that of Uslu (V_1) with all treatments.

Pulp Weight (g)

Statistical analysis of data (Table 2) regarding pulp weight showed that maximum pulp weight was 1.75 g in Uslu (V_1) while minimum 1.08 g was observed in Nochlerra (V_2) at T_2 and T_0, respectively. However, T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect while T_0 resulted in minimum pulp weight in both cultivars of olive (Table 3). Overall, maximum pulp weight was 1.47 g found in Uslu (V_1) with all treatments as compared to that of Nochlerra (V_2) which resulted in 1.35g.

Oil Contents (%)

Results demonstrated that

maximum oil contents was 18.3% in Uslu (V_1) while minimum 10.7% was observed in Nochlerra (V_2) at T_2 and T_0 respectively (Table 2). However, T_2 where GA_3 was applied @ 30 ppm caused more pronounced effect while T_0 resulted in minimum oil contents percentage in both cultivars of olive (Table 3). Overall, maximum oil contents was 14.6% found in Uslu (V_1) with all treatments as compared to that of Nochlerra (V_2) which resulted in 13.9%.

It is observed that GA_3 has more pronounced effect on olive growth and yield followed by girdling, NAA, SA and control. Variable response of PGRs might be due to fact that PGRs role depends upon the time of application, concentration and absorbed quantity (Rajput and Haribabu, 1985). Moreover, girdling provided better response than that of SA and NAA. It might be due to that girdling of olive trees had more pronounced effect to improve the internal hormonal and carbohydrate level of the canopy which is responsible for improving number of inflorescence (Levin and Lavee, 2005), flower number (Noor et al., 1995) fruit setting and fruit size in various olive cultivars (Proietti and Tombesi, 1990; Petrisou and Voyiatzis, 1994). Similarly, Mistra and Datta (2001) described a significant role of GA_{-3} in the induction of shoots buds on leaf segments of Marigold. Chaari-Rkhis et al. (2006) reported that gibberellic acid can play an important role in the induction of flowering process in olive tree. PGRs spray on fruit size has more pronounced effect as compared to control which is in agreement with Barros (1992) who reported that application of GA_3 alone or in combination increased the fruit diameter. The olive fruits contain a wide variety of phenolic compounds (Brenes et al., 1999; Mateos et al., 2001; Ryan et al., 2002; Bianchi, 2003; Owen et al., 2003) which depends upon type of olives, stage of maturity, season and/or climatic conditions (Romero et al., 2004). Overall performance of Uslu (V_1) was better as compared to Nochlerra (V_2) which indicates the existence of differential genetic potential.

By comparing means of treatments, it was concluded that there were significant effect of treatments for number of inflorescence, flower count, perfect flower percentage, flower drop, fruit set percentage, fruit size, fruit weight, pulp weight and oil contents while no such difference was observed for fruit drop percentage and fruit harvest percentage. However, Uslu (V_1) showed better response than that of Nochlerra (V_2) to all treatments.

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