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Influence of pollen source, complimentary pollination and micro-nutrients on productivity of kiwifruit cv. Hayward

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ABSTRACT

The present study was carried out on eleven year old vines of Hayward (female cultivar) and Tomuri and Matua (male cultivars) at Zangam orchard of Department of Horticulture (J&K) trained on T bar trellis system. The fruit set and yield characteristics of Hayward were significantly influenced by the pollen source. Among the various treatment combinations irrespective of the source of pollen, hand pollination at 90% bloom + spray of 0.1% borax ($Na_2B_4O_7.10H_2O$) and 0.4% $ZnSO_4$ enhanced both fruit set and yield characteristics. Tomuri cultivar proved to be a good pollen source for desired fruit characteristic, and hand pollination supplemented with boron and zinc exhibited beneficial effects on all the afore-mentioned parameters of pistillate cv. Hayward.

Key words: *Actinidia deliciosa*, micro-nutrients, pollination, pollen viability, yield

INTRODUCTION

Kiwifruit has emerged as a success story in temperate fruit growing areas of India. Hayward is most popular kiwifruit cultivar grown commercially worldwide. It accounts for 75 per cent of the global kiwifruit production and gained popularity due to its large fruit size, internal green colour, aesthetic appearance, superior flavour and extended storage life that is beneficial for international shipment and trade. Pollination of kiwifruit occurs mainly by honeybees and can also be artificially performed. Seed formation is the function of successful pollination and fertilization, and their number within a fruit has positive correlation with fruit weight, attained at the time of commercial maturity (Vasilakakis *et al.,*16). Approximately 1000-1100 seeds are required for 'Hayward' kiwifruit to reach 100 g weight. Inadequate pollination tends to produce the undersized and unmarketable fruits. In order to obtain the regular cropping with good marketable fruits, an alternative pollination system is needed. Alternative systems that have been evaluated are hand pollination, aqueous spray pollination and pollen dusting (Hopping and Hacking, 8). However information on the effects of pollen source on productivity of kiwifruit is scarce. Further, artificial pollination can lead to several positive metaxenic effects with respect to physico-chemical traits of berries.

Among nutrient elements, zinc and boron play an important role in pollination, fruit set and total yield. Zinc is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory factor for a variety of enzymes taking part in plant metabolism. It induces pollen tube growth through its role on tryptophan as an auxin precursor. It is possible to promote kiwifruit growth by exogenous application of plant-bioregulators *viz*., auxins, cytokinins, and gibberellins. Currently, the growth of kiwifruit requires the development of strategies to increase productivity, improving fruit size and quality, by proper pollination along with nutrient management practices. Thus the present study was undertaken to find the effect of source of pollen, complimentary pollination and micro-nutrients on overall productivity of kiwifruit cv. Hayward with particular reference to fruit set and yield attributing characteristics.

MATERIALS AND METHODS

The experiment was carried out during 2011 and 2012 in the orchard of Department of Horticulture at Fruit Nursery Zangam (Pattan), J&K (34.20^o N and 74.36^o E and 1578 m above mean sea level). The climate in general is of typical temperate type. Eleven year old kiwifruit vines of 'Hayward' (pistillate) and 'Matua', and 'Tomuri (staminate) cultivars were planted at 6m × 5m apart and trained on T-bar system. The vines were irrigated using drip irrigation, and all the vines were managed under strict schedule of cultural practices. The experiment was laid out in Randomized Block Design and replicated thrice (Table 1). For pollination studies, the flowers from both the male parents (Tomuri and Matua) were collected during morning hours (before 10 AM) at balloon stage, and the stamens were removed with the help of drying and sieving technique after placing on paper towel to

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Table 1. Treatment details tested in the study.

T_1	:	Hand pollination at 50% bloom
T_2	:	Hand pollination at 90% bloom
T_3	:	Hand pollination at 50% bloom + 0.1% $Na_2B_4O_7.10H_2O$
T_4	:	Hand pollination at 90% bloom + 0.1% $Na_2B_4O_7.10H_2O$
T_5	:	Hand pollination at 50% bloom + 0.4% $ZnSO_4$
T_6	:	Hand pollination at 90% bloom + 0.4% $ZnSO_4$
T_7	:	Hand pollination at 50% bloom + 0.1% $Na_2B_4O_7.10H_2O$ + 0.4% $ZnSO_4$
T_8	:	Hand pollination at 90% bloom + 0.1% $Na_2B_4O_7.10H_2O$ + 0.4% $ZnSO_4$
T_9	:	Natural pollination + 0.1% $Na_2B_4O_7.10H_2O$
T_{10}	:	Natural pollination + 0.4% $ZnSO_4$
T_{11}	:	Natural pollination + 0.1% $Na_2B_4O_7.10H_2O$ + 0.4% $ZnSO_4$
T_{12}	:	Natural pollination (control)

dry (25±2°C) for 24 h for anther dehiscence and pollen collection. For hand pollination, female flowers were bagged at the balloon stage to avoid uncontrolled pollination. Hand-pollination was carried out twice at 50 and 90 per cent full bloom. After 4 weeks of hand pollination, bags were removed to assess fruit set , and then fruits were secured with labeled tags. Micronutrient spray was done at the time of the bloom by using 5 liters of spray solution per vine. The pollen grains of both male cultivars were used to evaluate the *in vitro* germination and viability. The viability of pollen grains was tested by acetocarmine test and *in vitro* germination was assessed by hanging drop method. Fruit set and fruit retention characteristics were recorded as suggested by Westwood (17). For calculating the number of days from full bloom to maturity, the full bloom was marked on the day, when more than 80 per cent flowers had opened. Total number of fruits were counted at the time of harvest and expressed as number of fruits per vine. The yield was expressed in kilograms per vine (kg/vine). The fruits were separated into 3 grades on the basis of weight *viz*., A:>70 g, B: 50-70 g, C: <50 g. Average yield of different grades per vine was determined as per the method used by Thakur and Chandel (15).

RESULTS AND DISCUSSION

In the present investigation, the pollens of both the parents proved viable. The results revealed the higher for pollen viability in Tomuri (M_1) than Matua (M_2) during both the seasons of study (Table 2). These results are in agreement with Abreu and Oliveira

Table 2. Influence of staminate cultivars on the pollen viability and pollen germination of kiwifruit cv. Hayward (Pooled mean for two years data).

Code	Pollen parent	Pollen viability (%)	Pollen germination (%)
M_1	*Actinidia deliciosa* cv. Tomuri	87.57	92.19
M_2	*Actinidia deliciosa* cv. Matua	85.41	90.24
t-value/p-value		3.14 (0.0005)	2.95 (0.0002)

(1) who too reported 87 per cent viability of Tomuri pollen grains. However, Maria *et al.* (9) did not find any significant difference in respect of pollen viability and germination. High pollen viability may be due to pollen fertility as a result of regular meiosis and activation of certain enzymes present in the pollen itself. Both the male varieties yielded pollens having more than 90 per cent pollen germination. However, M_1 pollen source had higher germination percentage than pollen parent M_2 during both the seasons. The variation in pollen germination in different pollen sources of the same fruit crop may be attributed to the genotypic constitution of the cultivar, which ultimately produced pollen with different genetic makeup. Genotypic variability, temperature and physiological state of the pollen either singly or collectively might have contributed towards the variation in pollen grain germination (Petropoulou and Aliston, 12).

Pollination with different male parents significantly influenced the fruit set, fruit retention and days taken to maturity. Fruit set percentage of vines pollinated with M_1 was higher than M_2. The increase in fruit set was higher (3.41%) in vines pollinated with pollen donor M_1 than vine pollinated with pollen donor M_2 (Table 3). Variations in fruit settings with different pollen sources have also been reported earlier by El-Hammadi *et al.* (6). Among the different treatments, hand pollination at 90% bloom along with the combination of 0.1% borax and 0.4% zinc sulphate (T_8) resulted the maximum fruit set followed by Hand Pollination at 90% bloom and 0.1% borax (T_4). These results are in conformity with Antunes *et al.* (4) who reported higher fruit set, while pollens were applied at 90% opened bloom than 75%. Maria *et al*. (9) also recorded higher fruit set with hand pollination in kiwifruit. The beneficial effect of boron in increasing fruit set might be due to the higher availability of photosynthates and role in hormone metabolism, which promotes synthesis of auxin, essential for fruit set and growth. Boron has both direct and indirect effect on fertilization. These results are in agreement with Peryea *et al.* (11) who reported that fruit set increase could be due to enhanced

Table 3. Effect of pollen parent, complimentary pollination and micronutrient on fruit set and fruit retention in kiwifruit cv. Hayward (Pooled mean for two years data).

Treatment No.	Fruit set (%)			Fruit retention (%)		
	M_1	M_2	Mean	M_1	M_2	Mean
T_1	76.62	74.36	75.49	73.35	67.85	70.60
T_2	87.66	81.37	84.52	79.13	73.80	76.46
T_3	80.9	78.67	79.78	79.63	73.12	76.38
T_4	92.77	88.83	90.8	87.61	81.96	84.78
T_5	79.69	78.7	79.19	74.7	72.18	73.44
T_6	90.97	86.64	88.80	81.25	77.62	79.43
T_7	89.79	84.72	87.25	86.08	81.24	83.66
T_8	94.80	91.68	93.24	88.69	85.30	86.99
T_9	73.88	72.78	73.33	68.02	66.22	67.12
T_{10}	73.65	72.98	73.31	67.10	64.97	66.04
T_{11}	73.99	71.65	72.82	69.99	67.99	68.99
T_{12}	69.74	68.38	69.06	63.84	62.55	63.19
Mean	82.03	79.23		76.61	72.90	
CD (*P*≤*0.05*)	Treatment (T)	1.09			1.63	
	Pollen parent (M)	0.39			1.11	
	Interaction (T × M)	1.16			1.71	

M_1=Tomuri; M_2=Matua

pollen germination, tube growth and increased boron concentration in the pollens by foliar applied boron. in the enhanced fruit set with zinc sulphate has also been observed by Brahmachari *et al.* (5). The interaction between hand pollination with pollen from M_1 at 90% bloom in combination with 0.1% borax and 0.4% zinc sulphate significantly increased fruit set as compared to other interactions. These results are in agreement with Sumathi *et al.* (14) who concluded that instead of 100% pollen, 75% pollen with borax as filler material might be used without affecting the economic yield. Borax can be used as a supplement at the time of pollination. The cummulation of all the above factors might have resulted the enhanced fruit set during the course of present study.

Fruit retention percentage differed significantly between two pollen sources used. Increase in retention of fruits was higher using pollen parent M_1(5.05 %) compared to M_2 (Table 3). Variation in pollen viability and germination percentage were observed between the two sources which ultimately affected the retention of the fruit on the tree. The results on variation in fruit drop percentage are in confirmation with the findings of Ghalib *et al.* (7). Maximum fruit retention at the time of harvest was observed with Hand Pollination at 90% bloom in combination with 0.1% borax and 0.4% zinc sulphate (T_8). The fruit retention was significantly increased by pollination and micronutrient application. Al-Wusaibai *et al.* (3) also reported that manually pollinated palms had minimum fruit drop. Boron is known to be required for pollination and fertilization and also plays an important role on successive fruitlet retention. Furthermore, boron deficiency causes an alteration in the expression of a wide range of genes involved in several physiological processes, including boron uptake and translocation, maintenance of cell wall and membrane function, nitrogen assimilation, and plant stress response.

Pollination with pollen parent M_2 advanced the fruit maturity over M1 source of pollen (Table 4). However, Hand Pollination at 90% bloom along with 0.4% zinc sulphate (T_6) followed by Hand Pollination at 50% bloom in combination with 0.4% zinc sulphate (T_5) took minimum duration (days) to attain the stage of harvest maturity. Patterson (10) also reported that hand pollination could shorten the length of time from flowering to fruit maturity.

In the present study, significant differences were found regarding the effects of different pollen sources on the number of fruits per vine and fruit yield per vine (Table 4). The vines pollinated by pollen parent M_1 resulted the higher yield than M_2 pollinated vines. The variation in yield may be due to differences in pollen source, pollen viability, male and female compatibility (Al- Ghamdi *et al.*, 2). The differences in yield could be due to variation in pollen quality, percentage

Table 4. Effect of pollen parent, complimentary pollination and micronutrient on days taken to maturity and no. of fruits/vine in kiwifruit cv. Hayward (Pooled mean for two years data).

Treatment No.	Days taken to maturity			No. of Fruits/Vine		
	M_1	M_2	Mean	M_1	M_2	Mean
T_1	170.95	170.32	170.64	520.58	498.57	509.58
T_2	170.85	170.64	170.74	534.7	503.87	519.28
T_3	171.03	169.91	170.47	584.35	540.96	562.65
T_4	171.21	170.12	170.66	631.00	605.3	618.15
T_5	169.20	167.67	168.44	580.52	520.88	550.7
T_6	168.58	167.72	168.15	593.23	557.19	575.21
T_7	169.74	168.03	168.88	605.71	587.55	596.63
T_8	169.62	168.00	168.81	646.13	627.9	637.01
T_9	173.48	172.24	172.86	485.95	480.7	483.32
T_{10}	171.94	172.15	172.04	468.95	466.78	467.86
T_{11}	172.51	172.70	172.60	496.05	489.46	492.75
T_{12}	174.12	173.21	173.66	460.17	454.21	457.19
Mean	171.10	170.22		550.61	527.78	
CD ($P \leq 0.05$)	Treatment (T)	0.08			4.63	
	Pollen Parent (M)	1.11			2.29	
	Interaction (T × M)	0.04			4.71	

M_1=Tomuri; M_2=Matua

germination and pollen tube growth. It has also been suggested that pollen and growing pollen tubes release auxin, gibberellins, and other hormones, which are known to stimulate fruit set and growth in some species, even in the absence of normal seeds (Zhang *et al.*, 18). Pollen grains with higher viability might contain higher levels of growth stimuling substance, thus becoming the most vigorous gametophytes with the fastest-growing pollen tubes and, thereby, finally fertilizing the ovules in the competition, which ultimately resulted in, increased yield.

Hand Pollination at 90% bloom along with combination of both 0.1% borax and 0.4% zinc sulphate (T_8) resulted in highest number of fruits per vine and yield, and percentage of grade A fruits (Table 4-5). These results are in agreement with the findings of Singh *et al.* (13) who observed an increase in marketable fruit yield by foliar application

Table 5. Effect of pollen parent, complimentary pollination and micronutrient on yield (Kg/vine) and fruit grades of kiwifruit cv. Hayward (Pooled mean for two years data).

Treatment No.	Yield/vine (Kg)			Grade A (%)			Fruit grade Grade B (%)			Grade C (%)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	48.67	46.38	47.52	40.51	38.49	39.50	37.28	38.63	37.95	22.33	23.14	22.73
T_2	53.11	49.08	51.09	42.53	41.32	41.92	38.05	35.00	36.52	20.29	24.01	22.15
T_3	57.12	50.58	53.85	42.87	41.95	42.41	38.75	35.49	37.12	19.47	22.59	21.03
T_4	60.54	57.62	59.08	49.56	48.34	48.95	39.28	31.52	35.40	11.58	20.53	16.05
T_5	48.60	46.38	47.49	47.49	47.41	47.45	34.68	31.95	33.31	12.80	21.23	17.01
T_6	57.77	52.55	55.16	45.70	44.12	44.91	32.54	33.36	32.95	21.27	23.53	22.40
T_7	58.99	54.02	56.50	49.97	46.60	48.28	36.54	32.34	34.44	12.24	21.67	16.95
T_8	60.57	60.41	60.49	53.92	51.45	52.69	32.65	33.14	32.89	10.62	19.19	14.90
T_9	42.99	42.41	42.70	32.60	31.02	31.81	36.58	39.54	38.06	36.08	33.13	29.60
T_{10}	42.13	39.96	41.04	34.25	32.36	33.30	33.21	37.98	35.59	35.23	32.91	29.07

Contd...

Table 5 contd...

Treatment No.	Yield/vine (Kg)			Grade A (%)			Fruit grade Grade B (%)			Grade C (%)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_{11}	46.96	46.53	46.74	36.44	34.70	35.57	33.62	37.61	35.61	30.63	30.16	30.39
T_{12}	39.97	38.05	39.01	28.18	29.60	28.89	28.77	31.13	29.95	43.14	41.72	42.43
Mean	51.45	48.66		42.00	40.61		35.41	34.80		23.22	26.15	
CD ($P\leq0.05$)	Treatment (T)		0.98		1.19			1.07			0.46	
	Pollen parent (M)		0.71		NS			NS			NS	
	Interaction (T × M)		0.37		NS			NS			NS	

NS = Non significant; Grade A >70 g; Grade B = 50-70 g; Grade C <50 g; M_1=Tomuri ; M_2=Matua

of boron. The increase in yield due to zinc may be due to its beneficial effect on fruit set, growth and development. The combination of all the factors significantly increased the number of fruits per tree, yield of the plants due to the beneficial role of hand pollination, boron, and zinc.

AUTHORS' CONTRIBUTION

Conceptualization of research (Nowsheen Nazir); Designing of the experiments (Nowsheen Nazir, M. K. Sharma); Contribution of experimental materials (Aroosa Khalil); Execution of field/lab experiments and data collection (Nowsheen Nazir, Aroosa Khalil.); Analysis of data and interpretation (Nowsheen Nazir, Rafiya Mushtaq); Preparation of the manuscript (Rafiya Mushtaq).

DECLARATION

The authors declare no conflict of interest

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