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Effect of irrigation and mulching on growth, yield and quality of passion fruit (*Passiflora edulis* Sims.)

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ABSTRACT

An experiment was undertaken to study the effect of irrigation and mulching on passion fruit (Passiflora edulis Sims.) variety Kaveri and Purple in the hilly terrace area of Manipur. Growth, fruit yield and quality of passion fruit could be improved with the application of irrigation during dry months (November to March) in Manipur. Although irrigation at 10 days interval gave higher growth, irrigation at 15 days interval recorded higher fruit yield in both the varieties. Grass mulch recorded significantly higher growth, yield and quality over poly mulch and no irrigation. Among the different treatments, Kaveri variety recorded significantly higher growth, yield and quality than Purple.

Keywords: Growth, irrigation, moisture stress, passion fruit, TSS

Passion fruit is an attractive crop highly appreciated for fresh consumption and industrial purposes because of its diverse uses for juice, jelly and ice cream products (Knight and Sauls, 1994: Santos, 2002). The purple passion fruit is adapted to the cool subtropics or to high altitudes in the tropics within 650-1300 m MSL and rainfall ranging from 1000-2500 mm. In areas where the rains are insufficient or poorly distributed, irrigation is essential, not only to increase productivity, but also to improve the quality of the fruit and for continuous and uniform production (Oliveira *et al*., 2002). Rainfall must be well distributed as higher rainfall minimises insect activity, resulting in poor pollination, fruit set and fruit yields (Nakasone and Paull, 1998). Being long day plant, passion fruit requires more than 10 hours for flowering. It is a climacteric fruit and has vigorous perennial vine that is naturally supported by tendrils (Gamarra Rojas and Medina, 1997; Knight and Sauls, 1994; Morton, 1987).

Drought is a common environmental stress, generally characterised by a combination of water shortage, high temperatures and light intensities (Cornic, 1994; Lawlor, 1995). Photosynthesis and its capacity are progressively decreased under drought-induced stomatal closure, which reduces CO_2 availability in chloroplasts. Consequently lower light intensity is required to saturate photosynthesis under drought conditions than under well watered conditions. This may increase the susceptibility to photo inhibition and photo-oxidation (Osmond, 1994). In passion fruit dry soil conditions during drought lead to poor fruit set, shrivelled fruits, premature fruit drop and leaf defoliation which reduces the yield and quality (Owen, 1971; Morton, 1987; Ruggiero *et al*., 1996). In Brazil, increase of water availability reduced water use efficiency, and the simple increase of yield as a function of amount of water applied did not optimise the water used (Sousa *et al*., 2005). In India, the yield of passion fruit varies from 4-5 t ha^{-1}, but the expected yield potential is about 15-20 t ha^{-1}. Severe moisture stress coupled with low temperature during dry winter months (November-March) in Manipur leads to the huge gap between observed and potential yields. As the crop is a new introduction to Manipur there are no reports on the effect of irrigation and mulching on the production of passion fruit. With this backdrop, the study was undertaken.

MATERIALS AND METHODS

Experiments were conducted for three consecutive years 2005 to 2008 at Langol Hill Research Farm of ICAR Research Complex for NEH Region, Manipur Centre, Imphal (24°45'N, 93°54'E) on the terraces facing towards south west part of the hillock at an elevation of 810 m above mean sea level. The site experiences temperatures, ranging from 3.6-30.2^{0}C and average rainfall of 1340.6 mm. However, the plants received only 186.80 mm rainfall from November to March distributed over 18.2 days. The soils are acidic in nature with pH 5.00 and shallow in depth. The average monthly weather parameters during experimental period presented in fig.-1. The experiment was laid out in split plot design with four replications (five plants per replication) with passion fruit varieties Purple and Kaveri. Rooted cuttings were planted at 3 m distance (plant to plant) on the terraces spaced at 3 m apart. The plants were staked and later trained to draw secondaries from the main stem. Tertiaries from the secondaries were trained on to the four lined telephone system stretched with galvanised steel wires supported by iron angular posts

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on either side. The treatment combination involved two varieties in main plot *viz*., V_1-Kaveri (Hybrid) and V_2-Purple and at six levels of irrigation in sub plot *viz*., I_0- No irrigation, no mulching, I_1 – irrigation at 10 days interval, I_2 – irrigation at 15 days interval, I_3 – irrigation at 20 days interval, I_4 – Straw mulching without irrigation and I_5-Black poly-mulching in the plant basins without irrigation. Irrigation @16 litres was provided per day through drip irrigation during November to March (dry period). Recommended fertilizer dose of 100 kg N, 50 kg P and 100 kg K per hectare was applied at quarterly interval for three years, using urea, super phosphate and muriate of potash as N, P and K source, respectively. Grass mulch (10 cm thickness) and plastic mulch was provided one month after planting. Data were recorded on days to flowering, vine length, inernodal length, number of branches per vine, days to first flowering, fruits per plant, fruit weight, fruit yield per hectare, juice content and total soluble solids (TSS). Harvesting was done as soon as the fruits reached physiological maturity, indicated by colour change from green to a tinge of purple. TSS and juice content were measured on the ten randomly selected ripe fruits from each treatment using a hand-held refractometer (ERMA, Japan) and measuring cylinder (Borosil), respectively. The data were analyzed by analysis of variance (ANOVA) and means were compared at $P < 0.05$.

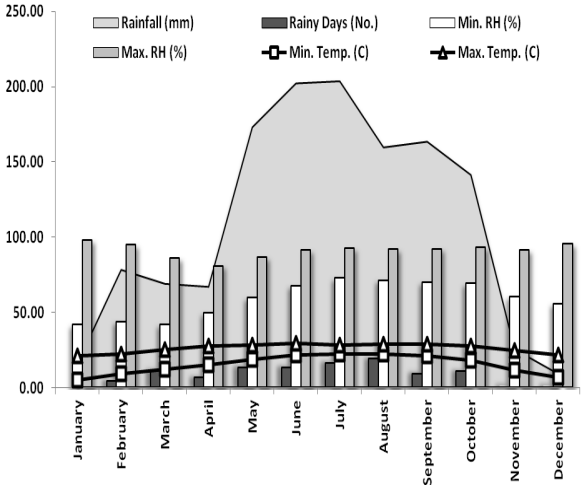


Fig. 1: Average monthly weather parameters during experimentation period

RESULTS AND DISCUSSION

Growth parameters

Varieties differed significantly in terms of days to flowering, vine length and intermodal length (Table 1). Among the two varieties, V_1 : Kaveri had taken longer days to flower (263.75 days) than V_2 : Purple (235.55 days). In terms of length of vine and internode, vigorous vine growth (176.00 cm) and longest internode (9.98 cm) were found in V_1 : Kaveri than V_2 : Purple (100.51 cm long vine and 6.20 cm long internode). Similarly, irrigation influenced all growth parameters significantly. Shortest duration for flowering (211.15 days) was recorded with I_5 : black poly-mulching in the plant basin; whereas, longest duration (325.82 days) was observed with I_0 : no irrigation. The longer days taken for flowering may be due to very low temperature during the winter months; whereas, black poly-mulching might have contributed to early flowering by maintaining the soil temperature. Temperatures below 15^0-18^0C restricts the vegetative growth and flowering. Among the different irrigation treatments, longest vine (176.15 cm) and longest internode (8.95 cm) were associated with I_1: irrigation at 10 days interval. Mulching with grass produced longer vine (129.15 cm) than black polythene (120.35cm). Plants with no irrigation (I_0) had shortest vine length (106.70 cm) as well as shortest internode (7.80 cm). Continuous availability of water boosted the plant growth and ensured protection from low temperature during stress period in irrigated plants. Manica (1981) and Ruggiero *et al.* (1996) reported that lack of moisture results in loss of leaves and fruits in passion fruit. Orellana *et al*., (2012) also reported that stem length and internodal length were significantly affected with irrigation. However, interaction effect between variety and irrigation on growth characters was non-significant except for days to flowering.

Yield attributes

Among the varieties, Kaveri (V_1) was found to be superior over Purple (V_2) in terms of number of fruits per plant (166.71 and 130.26, respectively), fruit weight (70.98 g and 26.59g, respectively) and fruit yield (13.33 t $ha^{-1}$and 3.97 t ha^{-1}, respectively). Irrigation also significantly affected different yield attributes (Table 2). Variety Kaveri is a high yielding hybrid variety obtained by crossing Purple and Yellow varieties and is tolerant to leaf spot, collar rot and wilt. Purple types are more productive and grown at higher elevations, but they are susceptible to collar rot and nematodes (Yadav and Patel, 2004). Purple passion fruit is shallow rooted and hence liable to drought stress (Gaturuku and Isutsa, 2011). The different levels of irrigation showed significant impact on the yield and yield contributing characters of passion fruit. Maximum number of fruits per plant (185.75) and highest fruit yield (11.20 t ha^{-1}) were recorded in I_2 : irrigation at 15 days interval, followed by I_1 : irrigation at 10 days interval (168.75 and 10.45 t ha^{-1}). However, heaviest fruits (55.78 g) were observed with I_1 : irrigation at 10 days interval, followed by I_2 : irrigation at 15 days interval (53.28 g). Plants raised without any irrigation (I_0) resulted in minimum number of fruits (106.03), fruit weight (39.78 g) and fruit yield (5.19 t ha^{-1}). The effect of

Table 1: Influence of irrigation and mulching on growth in two varieties of passion fruit

Treatments	Days to flowering	Length of vine (cm)	Internodal length (cm)
Kaveri (V_1)	263.75	176.00	9.98
Purple (V_2)	235.55	100.51	6.20
LSD (0.05)	**4.22**	**10.49**	**0.08**
No irrigation (I_0)	325.82	106.70	7.80
Irrigation at 10 days interval (I_1)	257.35	176.15	8.95
Irrigation at 15 days interval (I_2)	245.15	158.40	7.98
Irrigation at 20 days interval (I_3)	236.93	138.78	7.88
Straw mulching without irrigation (I_4)	221.50	129.15	7.95
Black poly-mulching in the plant basins (I_5)	211.15	120.35	8.00
LSD (0.05)	**8.04**	**8.08**	**0.12**
V_1 X I_0	337.40	153.40	9.90
V_1 X I_1	282.20	211.90	10.90
V_1 X I_2	270.20	193.10	9.50
V_1 X I_3	268.20	173.30	9.80
V_1 X I_4	231.20	158.30	9.90
V_1 X I_5	193.30	166.00	9.90
V_2 X I_0	314.24	60.00	5.70
V_2 X I_1	232.50	140.40	7.00
V_2 X I_2	220.10	123.70	6.45
V_2 X I_3	205.65	104.25	5.95
V_2 X I_4	211.80	100.00	6.00
V_2 X I_5	229.00	74.70	6.10
LSD (0.05)	**45.48**	**NS**	**NS**

Table 2: Influence of irrigation and mulching on yield in two varieties of passion fruit

Treatments	No. of fruits plant^{-1}	Fruit weight (g)	Fruit yield (t ha^{-1})
Kaveri (V_1)	166.71	70.98	13.33
Purple (V_2)	130.26	26.59	3.97
LSD (0.05)	**4.33**	**0.80**	**0.50**
No irrigation (I_0)	106.03	39.78	5.19
Irrigation at 10 days interval (I_1)	168.75	55.78	10.45
Irrigation at 15 days interval (I_2)	185.75	53.28	11.20
Irrigation at 20 days interval (I_3)	158.38	48.38	9.27
Straw mulching without irrigation (I_4)	143.50	48.38	8.47
Black poly-mulching in the plant basins (I_5)	128.50	47.15	7.33
LSD (0.05)	**4.86**	**1.05**	**0.37**
V_1 X I_0	128.00	57.85	8.34
V_1 X I_1	167.50	80.85	15.09
V_1 X I_2	195.50	77.15	16.61
V_1 X I_3	187.00	70.45	14.73
V_1 X I_4	171.00	71.15	13.61
V_1 X I_5	151.25	68.45	11.58
V_2 X I_0	84.05	21.70	2.04
V_2 X I_1	170.00	30.70	5.80
V_2 X I_2	176.00	29.40	5.79
V_2 X I_3	129.75	26.30	3.82
V_2 X I_4	116.00	25.60	3.33
V_2 X I_5	105.75	25.85	3.07
LSD (0.05)	**27.47**	**5.92**	**2.11**

interaction between varieties and irrigation on yield and yield contributing characters was also found to be significant. Maximum number of fruits per plant (195.50) and yield of fruits (16.61 t ha^{-1})

were recorded in Kaveri variety grown with irrigation at 15 days interval; whereas, maximum fruit weight (80.85 g) was found in Kaveri variety grown with irrigation at 10 days interval with average number of fruits per plant (167.50). Number of fruits per plant was found to be reducing with increase in interval of irrigation beyond 15 days. The results are in full agreement with the findings by Faust (1989). Significant difference was also recorded between the two mulch treatments *viz*., I_4: Straw mulching without irrigation (143.50 fruits plant^{-1}) and I_5: Black poly-mulching in the plant basin (128.50 fruits per plant).

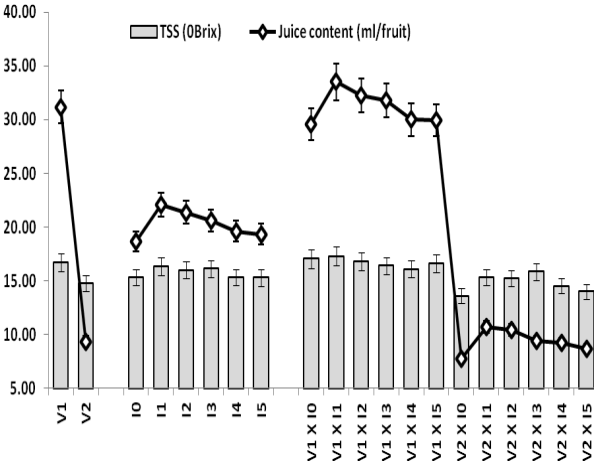
Both the varieties showed higher fruits per plant over I_0: no irrigation (106.03 fruits plant^{-1}) due to conservation of soil moisture around root zone. Lesser number of fruits per plant in the treatments viz., no irrigation (I_0), irrigation at 20 days interval (I_3), straw mulching without irrigation (I_4) and black poly-mulching in the plant basin (I_5) may be due to low water availability to the plants and the results also indicated that mulching is not sufficient to reduce the effect of moisture stress. Similarly, ability of the plants to develop more flowers due to availability of adequate moisture might have contributed for maximum number of fruits in I_2: irrigation at 15 days interval. Similar finding in passion fruit from Kenya was reported by Guturuku and Isutsa (2011). Vasconcelos (1994) also reported that soil water level influences flowering in passion fruit. Increased weight of fruit with increase in irrigation water could be due to role of irrigation water in dry matter synthesis and accumulation. Isutsa (2006) also reported that enough water is required for dry matter accumulation in fruits. Higher weight of fruit at different levels of irrigation was probably due to availability of water for plant growth during dry months. All the irrigation and mulch treatments recorded significantly higher fruit yield as compared to no irrigation (I_0). Thus, the plants receiving less water or no water could not overcome the moisture stress, concurring the observations of Isutsa (2006). Similar results were also reported by Jaimez *et al*. (2005) and Dorji *et al*. (2000) in pepper. The perusal of the data clearly indicated that application of higher amount of water can effectively reduce the stress and ensure higher growth, yield and quality in passion fruit.

Quality characters

Varieties significantly differed in fruit quality (Fig. 2). Higher total soluble solids and juice content were recorded in V_1: Kaveri (16.71^0 Brix and 31.18 ml fruit^{-1}) than V_2: Purple (14.77^0 Brix and 9.37 ml), respectively. Fruits from irrigated vines recorded significantly higher TSS and juice content than non-irrigated. Maximum TSS was recorded with I_1: irrigation at 10 days interval (16.33^0 Brix) and minimum with I_4: straw mulching without irrigation (15.05^0 Brix). This may be due to the fulfilment of adequate water for TSS synthesis. Guturuku and Isutsa (2011) also reported similar results in passion fruit. Highest juice content per fruit was observed with I_1: irrigation at 10 days interval (22.10 ml) and the lowest in I_0: no irrigation (18.68ml). Plants with I_4: straw mulching without irrigation (19.60 ml) were on par with I_5: Black poly-mulching in the plant basins (19.33 ml) in juice content, indicating that mulching did not affect the juice content significantly. Interaction of varieties and irrigation was found to be significant for TSS and non significant for juice content.

Fig. 2: Influence of irrigation and mulching on juice content and TSS in two varieties of passion fruit

Growing of passion fruit variety Kaveri with irrigation at 10 days interval under terraced condition would be helpful to improve the productivity as well as quality of passion fruit in Manipur by minimizing the moisture stress during winter months.



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