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Effect of irrigation systems and mulching on soil temperature and fruit yield of marrow (*Cucurbita pepo*) in temperate Himalaya of Uttarakhand

AC Mishra

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Abstract

Present investigation was conducted in the vegetable research block of Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Ranichauri, Tehri-Garhwal, Uttarakhand during summer seasons 2013 and 2014. The experiments were conducted with Bulam House F_1 hybrid of marrow (*Cucurbita pepo*) under two irrigation systems, drip and basin and by application of three types of mulch materials *viz*., black polythene (100 µm), white polythene (100µm) and dried grass mulching of 10 cm thickness applied @ 10.0 t/ha alongwith plots having no mulching *i.e.* bared soil. The experiments were laid out in two factors RBD with five replications. Results indicated that drip irrigation was consistently superior in relation to fruit yield (694.1 q/ha) over traditional system of basin irrigation (594.5 q/ha) in squash or marrow over two years. Mulch application resulted in 44.9-47.2% increase in fruit yield over the unmulched crop. Higher and *at par* fruit yield was realized by application of dried grass (705.1 q/ha) and black polythene mulches (704.9 q/ha). The interaction two treatment combinations indicated that black and white polythene mulches accompanied with drip irrigation exhibited high and *at par* fruit yield in marrow (*C. pepo*) over the years (797.6 q/ha and 788.5 q/ha, respectively) in the temperate hills of Uttarakhand Himalaya.

Keywords: Marrow, *Cucurbita pepo*, plastic mulch, organic mulching, soil temperature, temperate hills.

Introduction

An extensive area of Uttarakhand hills fall under rainfed conditions. Only 8-10% of agricultural lands falling in valleys (up to 1200 m altitude) are irrigated and covered with different vegetable crops in addition to rice and wheat. The temperate mid hill region of Himalaya in Uttarakhand (1750-2500 m altitude) is prevailed by scarcity of irrigation water and therefore, rainfed agriculture is specific feature of this region. Because of scarcity of soil moisture, a meager area remains under crop production during summer season. Certain vegetable crops requiring less water *e.g.* peas, beans, squash and capsicum are grown sporadically in this area during summer (March-June) by occasional drizzling or pot irrigation with drinking water supplied from valleys. Under such circumstances, use of water conservation technology *viz*., micro-irrigation and mulching in crop production becomes more relevant. Marrow (*Cucurbita pepo*) also known as summer squash, bush squash or chappan kaddu is one of the most popularly grown summer vegetables in Garhwal Himalays. Marrow is very much suitable crop for application of mulches and irrigation water through drip system as it is planted at sufficient inter-and intra-row spacing. The beneficial roles of drip irrigation in vegetable production in protected conditions as well as in open field have been well understood in relation to efficient use of water and nutrients by plants and saving of irrigation water rendering less soil moisture in inter-spaces of crop plants for weed seeds to grow (Dunage et al. 2005, Hakeem and Chand 2014). Production system using plastic mulch and drip irrigation commonly referred as plasticulture offers many benefits such as earliness, increased yield and quality, suppressed weed growth, improved irrigation and nutrient efficiency (Ban et al. 2009, Berihun 2011, Hatami et al. 2012, Kumar and Lal 2012, Kwabiah 2004) and soil moisture uniformity in rhizosphere. Plastic mulches have been found to increase soil temperature up to a great extent and therefore, could be more useful particularly in hilly areas where higher soil temperature is desirable for proper activity of root system of crop plants (Annda et al. 2008, Kumar and Lal 2012, Singh and Kamal 2012). In addition to conserving soil moisture, regulating weed population and soil temperature, organic mulches of dried grasses, forest litter or FYM have additional advantage to increase organic matter in the soil (Mishra and Pandey 2009). In

Department of Vegetable Science, College of Forestry, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Ranichauri, Tehri-Garhwal-249199, Uttarakhand
E-mails: acm24680@gmail.com, acm24680@rediffmail.com

the view of perpetuating water scarcity and beneficial effects of drip irrigation and mulching, an attempt was made to assess the extent of increase in yield of marrow over traditional system by using these water conservation technologies in temperate rainfed hills of Uttarakhand.

Materials and Methods

Experimental site: The experiments for present investigation were conducted in Vegetable Research Block of Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Ranichauri Campus, Tehri-Garhwal (2000 m altitude, $30^0 15'$ N latitude and $78^0 02'$ E longitude), the rainfed temperate hills of Uttarakhand during summer 2013 and 2014.

Experimental design and Treatments: The experiments were laid out in randomized block design with two factors, first consisted of two irrigation systems *viz*., drip and basin whereas, the second factor included application of three types of mulch materials *viz*., black polythene (100 µm), white polythene (100 µm) and dried grass mulching of 10 cm thickness applied @ 10.0 t/ha and fourth treatment having no mulching *i.e.* bared soil. All the treatment combinations were replicated five times in the plots of 4.0 x 2.5 m size.

Experimental materials and crop management: The trials were conducted a F_1 hybrid Bulam House, Seminis Seeds (India) Pvt. Ltd. The seeds were sown in polybags of 15cm x 7.5cm containing a mixture of soil and FYM. The seeds were sown in polybags during first week of March and were kept in polyhouse for 25 days till seedlings attained a height of 15-20 cm. The seedlings were transplanted in main field at 75 x 75 cm spacing on raised beds with installed drip system as well as plastic mulches as and where required. The soil of experimental field consisted of pH 6.4, organic matter 5.7% and NPK content of 347.5 kg/ha, 32.6 kg/ha and 564.8 kg/ha, respectively. The field was prepared with deep ploughing, clod breaking and mixing compost @ 15.0 t/ha. Prior to transplanting the field was prepared by mixing NPK 15:80:60 kg/ha, respectively in the form of DAP and MOP. Rest 85 kg N/ha was applied three split doses in the form of Urea in standing crop at 20 days, 40 days and 60 days after transplanting. The laterals of drip system with online/flat drippers of 16 mm OD/30 cm/2lph were placed on each row and the system was operates for 1.00-1.25 hr in each irrigation on alternate day. In the basin irrigation, plants were irrigated with pot at each fifth day. To avoid the crop from damage from hails, a most common problem during spring-summer in mid hills, the experimental plots were thatched with 50% shade nets.

Data recording for soil temperature and crop performance: The data on soil temperature at 2.0 PM of the day were recorded by inserting thermometer in soil up to 10 cm depth in each plot during the month of April and May and average soil temperature was worked out for each plot (Singh and Kamal 2012). The data were also recorded for days to first male and female flower initiation (days after transplanting, DAT), days to first harvest (DAT), number of fruits per plant and fruit yield (q/ha).

Results and Discussion

The data on soil temperature and crop performance under different irrigation systems and mulch materials have been depicted individually as well as in combinations in Table 1 & Table 2. It was evident that drip and basin irrigation system exhibited non-significant difference in relation to days to first female flower initiation and mean soil temperature in the both years. However, significant difference was noted for days to first male flower initiation during 2014. These two irrigation systems exhibited significant difference for days to first harvesting, number of fruits per plant and fruit yield with higher values for latter two parameters in drip system in both years (4.9 & 3.9 and 715.3 q/ha & 672.9 q/ha, respectively). Drip irrigated plots showed earlier harvesting in both the years (43.6 DAT and 41.8 DAT). High fruit yield in drip irrigation might be due to maintenance of consistently optimum moisture level in rhizosphere with proper aeration in soil. In basin irrigation, the water is poured in plant basins by flushing water from pot and it might have ultimately lead to de-aeration of soil in rhizosphere and also wider difference in soil moisture content during irrigation and inter-irrigation periods.

Significant effect of treatments with and without mulching has been observed on all the parameters studied. Earliest first male and female flower initiation and first harvesting was noted in white polythene mulching followed by black polythene mulching in both years. Maximum mean soil temperature was also recorded in white polythene mulching (31.6 ^{0}C in 2013 and 29.9 ^{0}C in 2014). Higher soil temperature in white polythene mulching might be associated with green house effect of white polythene leading to warming of underneath soil. White polythene mulching resulted in 4.6-5.1 ^{0}C rises in mean soil temperature. Similar results on rise in soil temperature as a result of plastic mulching has also been reported by Mohadeen (2014) and Singh and Kamal (2012). Mulching treatments did not differed significantly in respect of number of fruits per plant and fruit yield. However, mulched plots were better in

Table 1: Performance of marrow (*C. pepo*) hybrid as affected by different irrigation systems and mulch materials during summer 2013

Treatments	Days to first male flower initiation (DAT)	Days to first female flower initiation (DAT)	Mean soil temperature (^0C)	Days to first harvesting (DAT)	Number of fruits per plant	Fruit yield (q/ha)
Irrigation systems (I)						
Drip (I_1)	28.45	33.2	29.8	43.6	4.9	715.3
Basin (I_2)	28.00	33.0	29.1	45.1	4.2	617.8
CD (0.05)	1.2	0.60	0.72	0.82	0.1	16.8
Mulches (M)						
Black polythene (M_1)	26.6	32.8	28.8	44.6	5.0	718.5
White polythene (M_2)	25.9	31.1	31.6	42.7	5.1	721.9
Dried grasses (M_3)	29.9	33.7	30.9	44.2	5.1	724.2
Unmulched (M_4)	30.5	34.7	26.5	45.9	4.4	501.5
CD (0.05)	1.8	0.8	1.0	1.5	0.2	19.6
Interaction (I x M)						
I_1 x M_1	28.4	33.2	29.6	44.0	5.6	802.7
I_1 x M_2	24.8	30.8	31.6	41.2	5.9	816.3
I_1 x M_3	30.0	34.2	31.2	44.2	4.6	690.4
I_1 x M_4	30.6	34.6	26.8	45.0	4.4	551.6
I_2 x M_1	24.8	32.4	27.9	45.0	4.7	634.2
I_2 x M_2	27.0	31.4	31.6	44.2	4.7	627.4
I_2 x M_3	29.8	33.2	30.6	44.2	5.4	758.1
I_2 x M_4	30.4	34.8	26.2	46.8	4.4	451.4
CD (0.05)	2.5	1.1	1.5	1.6	0.3	13.6
CV (%)	6.9	8.5	3.8	7.9	4.7	35.9

Table 2: Performance of marrow (*C. pepo*) hybrid as affected by different irrigation systems and mulch materials during summer 2014

Treatments	Days to first male flower initiation (DAT)	Days to first female flower initiation (DAT)	Mean soil temperature (^0C)	Days to first harvesting (DAT)	Number of fruits per plant	Fruit yield (q/ha)
Irrigation systems (I)						
Drip (I_1)	26.1	30.2	28.2	41.8	3.9	672.9
Basin (I_2)	28.7	30.0	27.8	42.8	3.2	571.1
CD (0.05)	1.5	NS	0.9	NS	0.4	27.2
Mulches (M)						
Black polythene (M_1)	24.0	29.8	27.5	42.5	4.1	691.3
White polythene (M_2)	23.5	27.9	29.9	40.5	3.9	666.4
Dried grasses (M_3)	27.8	31.6	29.2	42.3	3.6	685.9
Unmulched (M_4)	29.5	31.2	25.3	43.8	2.8	456.7
CD (0.05)	2.4	1.1	1.6	1.2	0.5	38.4
Interaction (I x M)						
I_1 x M_1	23.0	30.5	28.2	42.0	4.9	792.5
I_1 x M_2	24.0	27.4	30.5	39.0	4.6	760.6
I_1 x M_3	28.0	31.6	28.6	42.5	3.2	634.4
I_1 x M_4	29.5	31.4	25.4	43.5	3.0	513.6
I_2 x M_1	25.0	29.0	26.7	43.0	3.3	590.0
I_2 x M_2	23.0	28.4	29.3	42.0	3.1	572.2
I_2 x M_3	27.5	31.5	29.8	42.0	4.0	737.5
I_2 x M_4	29.4	31.0	25.2	44.0	2.5	399.8
CD (0.05)	3.4	1.4	1.2	1.3	0.7	54.4
CV (%)	7.8	10.2	5.6	9.4	8.6	7.1

performance as compared to unmulched plot. Highest value of fruit yield was observed in dried grass mulching (724.2 q/ha in 2013 and black polythene mulching (691.3 q/ha) in 2014 with almost equal average fruit yield in these two mulching treatments (705.1q/ha and 704.9 q/ha, respectively). Mulching with white polythene sheets resulted in comparatively lower mean fruit yield in two years (694.2 q/ha) as compared to that in black polythene and dried grass mulching probably because of higher initial weed competition with marrow plants in white polythene mulching which would be drastically low in dried grass mulching and almost nil in black polythene mulching. The peculiar observation of present investigation was that 44.9-47.2% higher fruit yield in mulching treatment as compared to unmulched control and, dried grass mulching was as efficient as polythene mulching. Higher fruit yield in marrow under mulch application was probably due to favourable hydro-thermal regime of soil and weed-free environment. These findings were in consonance with those of Bhatt et al. (2011) and Mahadeen (2014) in squash; Ban et al. (2004), Ansary and Roy (2005), Cenobio et al. (2007) and Parmar et al. (2013) in watermelon. The beneficial effect of dried grass mulching on fruit yield might be due to better aeration of rhizosphere, better microbial build up in underneath soil and also release of additional nutrients in soil consequent upon decomposition of dried grasses in later stages of plant growth and development (Mishra and Pandey 2009). Due to microbial activity during decomposition of dried grasses, the temperature of underneath soil is also increased leading to better activity of root hairs in uptake and translocation of nutrients (Ban et al. 2009).

The interaction of irrigation systems and mulch application also exhibited a significant influence on all the parameters studied. The treatment combination involving drip system and white polythene showed earliest first male and female flower initiation and first harvesting in both years. Maximum mean soil temperature was also noted in this treatment combination (31.6 ^{0}C and 30.5 ^{0}C). White polythene mulching in drip irrigation resulted in 5.3-5.4 ^{0}C rise in mean soil temperature as compared to unmulched control under basin irrigation. As far as number of fruits per plant and fruit yield were concerned, maximum values for these parameters were observed in drip irrigation and white polythene mulching during 2013 (5.9 and 816.3 q/ha, respectively) and drip irrigation and black polythene mulching during 2014 (4.9 and 792.5 q/ha). The treatment combination drip irrigation and black polythene mulching exhibited maximum fruit yield over the years (797.6 q/ha) closely followed by drip irrigation and white polythene mulching (788.5 q/ha).

On the basis of above discussion, it could be concluded that drip irrigation was consistently superior in relation to fruit yield (694.1 q/ha) over traditional system of basin irrigation (594.5 q/ha) in squash or marrow over two years. Mulch application resulted in 44.9-47.2% increase in fruit yield over the unmulched crop. Higher and *at par* fruit yield was realized by application of dried grass (705.1 q/ha) and black polythene mulches (704.9 q/ha). The interaction two treatment combinations indicated that black and white polythene mulches accompanied with drip irrigation exhibited high and *at par* fruit yield in marrow (*C. pepo*) over the years (797.6 q/ha and 788.5 q/ha, respectively) in the temperate his of Uttarakhand Himalaya.

सारांश

वर्तमान परीक्षण वीर चन्द्र सिंह गढ़वाली, उत्तराखण्ड औद्यानिकी एवं वानिकी विश्वविद्यालय, रानीचौरी परिसर, टिहरी गढ़वाल (उत्तराखण्ड) के सब्जी शोध प्रक्षेत्र में वर्ष 2013 एवं 2014 के ग्रीष्म ऋतु में किया गया। परीक्षण में मैरो (*कुकुरबिटा पेपो*) की संकर किस्म ''बुलमहाउस'' में तीन पलवार साम्रगी 100 माइक्रॉन मोटाई की काली पॉलीथीन, सफेद पॉलीथीन तथा 10 से.मी. मोटी (प्रति हेक्टेयर 10 टन) सूखी घास को पलवार के रूप में प्रयोग करते हुए पलवार रहित परती भाग में दो सिंचाई विधियों थाले में सिंचाई एवं ड्रिप के प्रभाव पर अध्ययन किया गया। इस प्रयोग को पांच प्रतिकृति युक्त द्विकारक रैन्डमाइज्ड ब्लॉक डिजाइन में सम्पादित किया गया। दो वर्ष के परिणाम से स्पष्ट हुआ कि फल उपज की दृष्टिकोण से पारम्परिक विधि यानि थाले में सिंचाई (594.5 कुन्तल प्रति हेक्टेयर) की अपेक्षा ड्रिप सिंचाई से अधिक उपज उपज (694.1 कुन्तल प्रति हेक्टेयर) प्राप्त हुआ। पलवार रहित फसल की अपेक्षा पलवारयुक्त उपचारों से 44.9 प्रतिशत से 47. 2 प्रतिशत अधिक फल उपज प्राप्त हुआ। सूखी घास एवं काली पॉलीथीन के पलवार प्रयोग से उच्च एवं लगभग बराबर फल उपज (प्रति हेक्टेयर क्रमशः 705.1 कुन्तल एवं 704.9 कुन्तल) प्राप्त हुआ। दोनों कारकों के पारस्परिक प्रभाव से स्पष्ट होता है कि उत्तराखण्ड के शीतोष्ण हिमालय क्षेत्र में मैरो फसल में काले अथवा सफेद पॉलीथीन के पलवार के साथ ड्रिप सिंचाई से उच्चतम तथा लगभग बराबर फल उपज (क्रमशः 797.6 कुन्तल तथा 788.5 कुन्तल प्रति हेक्टेयर) प्राप्त किया जा सकता है।

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