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Dr. NR Dalal
Assistant Professor,
College of Horticulture, Pune,
Maharashtra, India

Dr. MN Bhalekar
Sr. Vegetable Breeder, AICRP on Vegetable Crops, Dept. of Horticulture, MPKV, Rahuri, Maharashtra, India

Dr. SA Ranpise
Department of Horticulture, MPKV, Rahuri, Maharashtra, India

Dr. SR Dalal
Head of Section (Hort), College of Agriculture, Dr. PDKV, Akola, Maharashtra, India

Corresponding Author:
Dr. NR Dalal
Assistant Professor,
College of Horticulture, Pune,
Maharashtra, India

Irrigation water management on growth, flowering and yield of drumstick (*Moringa oleifera* Lamk.) cv. Bhagya

Dr. NR Dalal, Dr. MN Bhalekar, Dr. SA Ranpise and Dr. SR Dalal

Abstract
The experiment entitled Irrigation water management on growth, flowering and yield of drumstick (*Moringa oleifera* Lamk.) cv. Bhagya was conducted at AICRP on Vegetable Crops, MPKV, Rahuri during the years 2014-15 and 2015-16 to study the effect of different water regimes on growth, flowering and yield of drumstick pod. The level of 100% irrigation given up to May (as per requirement) i.e. without deficit, recorded minimum first branching height 51.18 (cm), 100% irrigation up to May to border row plantation obtained maximum number of primary branches (4.84) and canopy spread(11.20 m^2). In case of flowering parameter, minimum days to 50% flowering of 1 st (101.54) and 2nd (138.83) flush observed in 100% irrigation up to January (as per requirement). Irrigation level 100% given up to March (as per requirement) i.e. without deficit and 66% irrigation up to May (1/3 deficit) recorded maximum pod length (59.66), pod yield (20.58 kg/plant) and number of seeds per pod (18.44).

Keywords: Drumstick, *Moringa oleifera*, water management, Rahuri

Introduction
Drumstick (*Moringa oleifera* Lamk.) a perennial unexploited vegetable crop belongs to the family Moringaceae. It is native to North-West India and has a wide distribution ranging from warm tropical climate of sea coast to sub tropical climate of sub Himalayan tract. Drumstick is a popular vegetable in South West India, particularly in Maharashtra, Tamil Nadu and Kerala. Drumstick or moringa tree also known as horseradish tree and ben tree in English, mungna, saijna and shajna in Hindi. Almost all parts of the drumstick tree are used for one or the other purpose. It is considered to possess high medicinal value as it is widely used for treatment of ascites, rheumatism, bites and as a cardiac and circulatory stimulant. The tender leaves contain two alkaloids namely moringine and moringinine (Peter, 1979) [11] and are known to reduce blood glucose level by 15 per cent (Mossa, 1985) [10]. The drumstick pod, seed, leaves and flowers are consumed by humans as nutritious vegetable in some countries (Makkar and Becker, 1997) [9]. Maharashtra state is prominently characterized with sub-mountain region with shallow to medium soil depth and nine agro-climatic zones. However most of the area comes “under Scarcity Agro-climatic Zone”. Even though potential of drumstick cultivation in Maharashtra state has been increasing since 2000 but drumstick cultivation has to be precisely standardized with minimum drip irrigation level at various crucial plant growth conditions, particularly under scarcity zone where annual rainfall range in between 300-700mm. Drumstick is predominantly a crop of dry and arid tracts. However intensive cultivation with good irrigation and systematic cultural practices will give good yield especially for annual types. Cultivar Bhagya (KDM-1) is a drumstick variety recommended by University of Horticultural Sciences, Bhagalkot for its early bearing, self pruning type and high yield and quality pods of 60-70 cm long. It has been getting good popularity in states of Andhra Pradesh, Karnataka and adjoining regions of Maharashtra. Standardization on production technology for this variety is still to be achieved particularly in Maharashtra. Considering commercial, industrial and medicinal value of Drumstick it is necessary to undertake systematic research on production technology including water requirement and canopy management. Even though there are several reports for potential drip irrigation to drumstick orchard but meager information is available on deficit water management. Hence, under this investigation two main strategies are involved, under first part, as per plant growth requirement irrigation is made available under four main treatments i.e. up to first flowering (Oct), second flowering (Dec), 50% pod harvesting (March) and 100% pod harvesting (May). While as water scarcity is the salient feature of Scarcity zone that too under light and shallow soils, the more meaningfully, severe deficit (2/3 or 66%) and light deficit (1/3 or 33%) irrigation level are evaluated for their effect on plant growth, pod yield and quality.

Also in present investigation, border row plantation (with and without irrigation) is also included as a special demand from farmers. With this contest, the present investigation, entitled "Irrigation water management on growth and yield of drumstick (*Moringa oleifera* Lamk.) cv. Bhagya (KDM-1) was planned and conducted during the year 2014-15 and 2015-16.

Materials and methods

The present investigation entitled "Irrigation water management on growth and yield of drumstick (Moringa oleifera Lamk.) cv. Bhagya (KDM-1)" was carried out during the year 2014-15 and 2015-16. The treatment consists of

T1: Rainfed (Control - I)
T2: 100% irrigation up to January (as per requirement)
T3: T2 + 33% irrigation up to May (2/3 deficit)
T4: T2 + 66% irrigation up to May (1/3 deficit)
T5: 100% irrigation up to March (as per requirement) i.e. without deficit
T6: T5 + 33% irrigation up to May (2/3 deficit)
T7: T5 + 66% irrigation up to May (1/3 deficit)
T8: 100% irrigation up to May (as per requirement) i.e. without deficit
T9: Rainfed border row plantation (Control - II)
T10: 100% irrigation up to May to border row plantation

The spacing of the crop is 2.5 X 2.5 m. The experiment was conducted in Randomized Block Design with three replications. The variety used for study is Bhagya (KDM-1) is recommended by University of Horticultural Sciences, Bhagalkot for its early bearing, self pruning type and high yield and quality pods of 60-70 cm long. The canopy management practices were followed as per recommendations. The observations on growth and yield parameters were recorded at the time of flowering and pod harvesting of the crop.

Result and discussion

First branching height (cm)

The pooled data presented in Table 1 revealed that, the treatment, 100% irrigation up to May as per requirement (T_8) i.e. without deficit, raised first branching at the lowest height (51.18 cm) whereas, highest first branching height (52.34 cm) was noticed in the treatment T_4 i.e.100% irrigation up to January as per requirement. The treatment 100% irrigation up to May as per requirement (i.e. without deficit) raised first branching at the lowest height. This finding is in the accordance of Raja *et al.* (2009) [12] in drumstick plant.

Number of primary branches

The pooled data presented in Table 1 revealed that, the treatment, 100% irrigation up to May to border row plantation (T_{10}) produced significantly maximum number of primary branches per plant (4.84 cm) in pooled analysis. The minimum number of primary branches per plant (4.37 cm) were recorded in the treatment T_1 (i.e. control-I) and in Rainfed orchard plantation in pooled analysis. Number of branches is the important morphological character contributing for spread of canopy. The similar results were reported by Antony and Singandhupe (2003), Gadissa and Chemeda (2009) [7], and Chauhan *et al.* (2013) [4] in Brinjal.

Canopy spread (m^2)

The pooled data presented in Table 1 revealed that, the treatment, T_{10} (100% irrigation up to May to border row plantation), recorded significantly maximum canopy spread (11.26 cm in pooled analysis, however, it was at par with the treatment T_7 i.e.100% irrigation up to March as per requirement and it was followed by 66% irrigation up to May (10.89 cm) and 100% irrigation up to May (T_8)as per requirement i.e. without deficit (10.55 cm) This might be due to sufficient soil moisture available for pronounced crop growth which supported in maximum absorbance of moisture by the crop and reflected in maximum number of primary branches and stem girth which leads to increased plant spread. These findings are in accordance with the by Byari and Al-Syed (1998) [3], Farghali (1998) [6] and Colak *et al.* (2015) [5].

Days to 50% flowering of 1st flush

The pooled data presented in Table 1 revealed that, the treatment, T_2 (100% irrigation up to January as per requirement), took significantly minimum days to 50% flowering of 1st flush after transplanting and after beheading (101.54**)**. The maximum days required to 50% flowering of 1st flush at days after transplanting and days after beheading (110.35 cm) in the treatment T_1 (Rainfed, i.e. Control- I). As concerned with days to 50 % flowering of 1st flush, the intensity of irrigation showed significant influence on it, as the moisture stress increased, there was reduction in the number of days required for days to 50 % flowering was noticed during both the years and in pooled results. The current results are in agreement to a great extent with those reported by Beaulah (2001) [2], Rajeswari and Mohindeen (2004) [13] and Goswami *et al.* (2006) [8].

Days to 50% flowering of 2nd flush

The pooled data presented in Table 1 revealed that, the treatment, T_2 (100% irrigation up to January as per requirement), recorded significantly minimum days to 50% flowering of 2nd flush after transplanting and after beheading (138.83**)**. The maximum days to 50% flowering of 2nd flush showed after transplanting and after beheading (151.67) in the treatment T_1 (Rainfed i.e. Control- I). As the moisture stress increased, there was reduction in the number of days required for days to 50 % flowering was noticed during both the years and in pooled results. The current results are in agreement to a great extent with those reported by Beaulah (2001) [2], Rajeswari and Mohindeen (2004) [13] and Goswami *et al.* (2006) [8].

Pod length for each flowering flush (cm)

The pooled data presented in Table 1 revealed that, the treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), registered largest pod length for each flowering flush (59.66), whereas, the smallest pod length for each flowering flush (51.97).

Number of seeds pod^{-1} for each flowering flush

The pooled data presented in Table 1 revealed that, treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), recorded maximum number of seeds pod^{-1} for each flowering flush (18.44) respectively, however, it was at par with the treatment T_8, 100% irrigation up to May as per requirement i.e. without deficit (17.69). Significantly minimum number of seeds pod^{-1} for each flowering flush (14.97) was recorded in T_9, Rainfed border row plantation (i.e. control-II), however, it was at par with T_1 (15.04), T_2 (15.20) and T_3 (15.54) during both the years under study and in pooled analysis, respectively.

Pod yield (kg plant^{-1})

The pooled data presented in Table 1 revealed that, treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), recorded maximum pod yield plant^{-1} from both the flushes of main crop (10.38) during 2014-15 and in ratoon crop (20.58) during 2015-16, however, it was at par with the treatment $T_{10,}$ 100% irrigation up to May to border row plantation (10.18) and $T_{8,}$ 100% irrigation up to May as per requirement i.e. without deficit (9.72) in main crop during 2014-15 and $T_{10,}$ (19.32) $T_{8,}$ (19.18) and $T_{6,}$ 100% irrigation up to March and then 33% irrigation up to May i.e. 2/3 deficit (18.30) in ratoon crop during 2015-16.

Pod yield (t ha^{-1})

The data pooled data regarding pod yield hactare-1 from two flushes as influenced by different deficit irrigation water regimes are presented in Table1. The treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), recorded maximum pod yield hectare -1 (32.94 t) followed by T_8 (30.68 t) and T_6 (29.27 t). The minimum pod yield hectare -1 from two flushes (15.63 t) was recorded in T_1, Rainfed orchard plantation (i.e. control-I) and it was at par with the treatment T_2 i.e. 100% irrigation up to January as per requirement (16.55 t). As the per hectare plant population in border row plantation was 160 and in rest of the treatments per hectare plant population was 1600, therefore, per hectare yield of border row plantation was not calculated. This might have resulted due to optimum irrigation regimes i.e. 100% up to March as per requirement and then 66% irrigation up to May which maintained the soil moisture at field capacity throughout the crop growth period resulting optimum absorption of moisture which enhanced all the growth attributes of the crop resulted in maximum absorbed Photosynthetically Active Radiation (PAR) accompanied with higher rate of photosynthesis and dry matter accumulation reflected in efficient translocation of photosynthates towards reproductive parts helped in increase in number of pods and pod weight and girth which ultimately resulted in increase in drumstick pod yield under the non-stress condition.

Table 1: Irrigation water management on growth, flowering and yield of drumstick (*Moringa oleifera Lamk.*) cv. Bhagya

Sr. No.	Tr. No.	Treatments	first branching height (cm)	number of primary branches	canopy spread (m2)	Days to 50% flowering of 1st flush	Days to 50% flowering of 2nd flush	Pod length (cm)	Number of seeds/ pod	Pod yield (kg/plant)	Pod yield (t/ ha)
1.	T_1	Rainfed (Control -I)	51.65	4.37	8.32	110.35	151.67	51.97	15.04	9.77	15.63
2.	T_2	100% irrigation up to January (as per requirement)	52.02	4.43	8.45	101.54	138.83	52.22	15.20	10.35	16.55
3.	T_3	T_2 + 33% irrigation up to May (2/3 deficit)	51.87	4.61	8.88	102.59	140.92	54.17	15.54	12.91	20.65
4.	T_4	T_2 + 66% irrigation up to May (1/3 deficit)	52.34	4.78	9.52	104.71	140.88	55.12	16.13	15.33	24.53
5.	T_5	100% irrigation up to March (as per requirement) i.e. without deficit	51.43	4.68	9.75	105.46	142.34	55.82	16.47	16.15	25.83
6.	T_6	T_5 + 33% irrigation up to May (2/3 deficit)	51.23	4.41	9.95	105.67	142.25	56.85	16.67	18.30	29.27
7.	T_7	T_5 + 66% irrigation up to May (1/3 deficit)	51.28	4.74	10.89	106.37	142.76	59.66	18.44	20.58	32.94
8.	T_8	100% irrigation up to May (as per requirement) i.e. without deficit	51.18	4.67	10.55	105.83	142.17	57.23	17.69	19.18	30.68
9.	T_9	Rainfed border row plantation (Control - II)	52.26	4.60	8.35	109.71	147.73	53.30	14.97	10.02	---------
10.	T_{10}	100% irrigation up to May to border row plantation	51.79	4.84	11.26	105.98	142.91	58.38	17.27	19.32	---------
		SE(m)±	0.41	0.13	0.28	0.07	0.05	2.35	0.26	0.91	1.35
		CD at 5%	N.S.	N.S	0.81	0.20	0.16	N. S.	0.76	2.69	4.09

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