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Deficit irrigation water management on growth and yield of drumstick (*Moringa oleifera* Lamk.) cv. Bhagya

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Abstract
The experiment on Deficit Irrigation water management on growth and yield of drumstick (Moringa *oleifera* Lamk.) cv. Bhagya were conducted at AICRP on Vegetable Crops, MPKV, Rahuri during the year 2014-15 and 2015-16 to study the effect of different water regimes on growth and yield of drumstick pod. The irrigation level of 100% irrigation up to March as per requirement and then 66% irrigation up to May obtained maximum yield and soil moisture content as compared to the other levels of irrigation during both the years of investigation. The average emission uniformity values were found greater than 90%, indicating nearly uniform water application throughout the crop growth period.

Keywords: Water management, yield, drumstick

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 is one of the world's most useful crops and is a tropical tree with multiple uses and its main feature is that it is hardy with tremendous capacity to withstand drought, as, it is considered to be a dry land vegetable crop, requires less water. However, production technology under these conditions is not yet standardised. Thus, it is necessary to standardise water requirement technique for canopy management in this crop. The research in Drumstick on water stress is under explored and needs further study. Moringa is considered to be a most potential remunerative perennial vegetable crop for dry land situations and can be grown as pure crop or on borders along the bunds and suits very well in agri-horti-silvi programme. It has been found to grow and yield satisfactorily in all types of soils but sandy loams containing good amount of lime are said to be preferable. 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.
The present investigation was particularly undertaken with Drumstick as it is the only dry land vegetable tree crop which has the great promise for sustainable horticulture especially under Scarcity Agro-climatic zones. But it is neglected one and need investigation on many aspects. 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 "Deficit Irrigation water management on growth and yield of drumstick (*Moringa oleifera* Lamk.) cv. Bhagya.

Materials and methods
The present investigation entitled "Deficit 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

T_1 : Rainfed (Control - I)
T_2 : 100% irrigation up to January (as per requirement)
T_3 : T_2 + 33% irrigation up to May (2/3 deficit)
T_4 : T_2 + 66% irrigation up to May (1/3 deficit)
T_5 : 100% irrigation up to March (as per requirement) i.e. without deficit
T_6 : T_5 + 33% irrigation up to May (2/3 deficit)
T_7 : T_5 + 66% irrigation up to May (1/3 deficit)
T_8 : 100% irrigation up to May (as per requirement) i.e. without deficit
T_9 : Rainfed border row plantation (Control - II)
T_{10} : 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

The pooled data presented in Table 1 revealed that, the treatment receiving 100% irrigation up to May as per requirement i.e. without deficit recorded significantly highest plant height (4.52 m) followed by the treatment $T_{10,}$ i.e.100% i.e.100% irrigation up to May to border row plantation (4.48 m). The 100% irrigation up to May as per requirement i.e. without deficit recorded significantly highest plant height in drumstick. The lowest plant height (3.73 m) was recorded in the treatment $T_{9,}$ i.e. control-II, (Rainfed border row plantation). Hussein *et al*. (2014) [7] in drumstick and Chitra *et al*. (2017) [4] in turmeric. They show that increase percentage of moisture depletion (i.e. increase water stress) led to decrease the plant height.

The treatment receiving 100% irrigation up to May to border row plantation produced significantly maximum stem girth (41.83 cm) and found at par with the treatment T_7 - 100% irrigation up to March and then 66% irrigation up to May (41.70 cm), T_8- 100% irrigation up to May as per requirement i.e. without deficit (40.63cm) and T_6- 100% irrigation up to March and then 33% irrigation up to May (39.87 cm). The minimum stem girth (33.86 cm) was observed in the treatment T_1 (i.e. control-I), Rainfed orchard plantation.

The treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), obtained significantly maximum number of leaflets per branch (40.46) however, it was at par with the treatment T_{10} (39.43), T_8 {38.46) and T_6 (36.56) during both the years of study and in pooled analysis also. The minimum number of leaflets per branch (29.16) was obtained in the treatment, $T_{1,}$ (Rainfed i.e. control-I).

The pooled data indicated that, the treatment receiving 100% irrigation up to January as per requirement recorded significantly minimum days to 1st flowering flush after transplanting and after beheading (83.00 days**)** over all other treatments, whereas, the maximum days required to 1st flowering flush (89.87 days) in the treatment $T_{1,}$ Rainfed (i.e. control-I). Similarly, the treatment, T_2 (100% irrigation up to January as per requirement), noticed significantly minimum days to 2nd flowering flush after transplanting and after beheading. (120.21 days**)**, however, the maximum days were required to 2nd flowering flush (132.08 days) in the treatment T_1 (Rainfed i.e. Control- I). As concerned with days to 1st flowering flush, the intensity of irrigation showed significant influenced on it. The 100% irrigation up to January as per requirement recorded significantly minimum days to 1st flowering flush after transplanting and after beheading, while maximum days to 1st flowering flush was observed under Rainfed, i.e. Control- I. As the moisture stress increased, there was reduction in the number of days required for days to 1st flowering flush 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) [1], Rajeswari and Mohindeen (2004) [10] in drumstick.

The treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), noticed maximum average pod weight from each flush (64.32 g) while it was minimum in Rainfed control treatment (52.02 g).

The treatment showed significant variation due to different deficit irrigation levels in respect of pod girth. The treatment, T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May), recorded significantly maximum pod girth (5.85 cm), however, it was at par with the treatment T_{10} (5.77 cm), T_8 (5.67 cm) and T_6 (5.53 cm) during both the years of study and in pooled analysis. The minimum pod girth was recorded on Rainfed control treatment (4.61cm).

Scheduling of 100% irrigation up to March as per requirement and then 66% irrigation up to May, recorded maximum pod weight and pod girth for each flowering flush The minimum pod girth for each flowering flush was recorded in the rainfed orchard plantation treatment. This might be due to minimum stress condition owing to its luxurious growth, more absorbed PAR, photosynthesis rate and dry matter accumulation resulted in maximum pod size in respect of pod length, pod girth and average weight of pod. Similar results were postulated by Gupta *et al.* (2009) [6], Owusu and Annan (2010) [8] and Colak *et al.* (2015) [5].

The pooled data pertaining to the number of pods plant $^{-1}$ from each flush as influenced by different deficit irrigation water regimes to drumstick are presented in Table 1. The significant differences were observed due to various deficit irrigation treatments.

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

	Treatment	Plant height (cm)	Stem girth (cm)	No. of leaflet per branch	Days to first flowering flush	Days to second flowering flush	Pod weight (g)	Pod girth (cm)	No. of pods per plant	Pod yield t/ha.
T_1	Rainfed **(Control -I)**	3.76	33.86	29.16	89.87	132.08	52.05	4.61	188.07	15.63
T_2	100% irrigation up to **January** (as per requirement)	3.79	36.25	31.50	83.00	120.21	53.61	4.88	192.27	16.55
T_3	T_2 + 33% irrigation up to May (2/3 deficit)	3.89	37.70	32.70	83.70	122.65	55.10	4.97	231.94	20.65
T_4	T_2 + 66% irrigation up to May (1/3 deficit)	4.13	38.40	34.43	84.27	123.71	58.82	5.20	269.17	24.53
T_5	100% irrigation up to March (as per requirement) i.e. without deficit	4.37	39.67	35.41	84.87	124.33	59.36	5.49	284.20	25.83
T_6	T_5 + 33% irrigation up to May (2/3 deficit)	4.29	39.87	36.56	85.80	125.25	60.81	5.53	302.20	29.27
T_7	T_5 + 66% irrigation up to May (1/3 deficit)	4.46	41.70	40.46	86.09	126.25	64.32	5.85	328.33	32.94

T_8	100% irrigation up to May (as per requirement) i.e. without deficit	4.52	40.63	38.46	86.80	126.00	62.66	5.67	306.74	30.68
T_9	Rainfed border row plantation (Control -II)	3.73	35.72	29.43	88.92	129.71	52.45	4.85	190.54	--
T_{10}	100% irrigation up to May to border row plantation	4.48	41.83	39.43	87.05	125.30	61.09	5.77	317.00	--
	SE(m)±	0.12	1.35	1.57	0.18	0.19	2.43	0.11	11.52	1.35
	CD at 5%	0.36	4.01	4.51	0.53	0.55	7.21	0.34	34.22	4.09

(The treatment T_9 & T_{10} are border row plantation having per hectare plant population was 160, hence, these treatments are not considered for pod yield per hectare.)

The treatment receiving T_7 (100% irrigation up to March as per requirement and then 66% irrigation up to May) recorded significantly maximum number of pods plant $^{-1}$ from each flush (328.33). However, it was at par with the treatment T_{10}- 100% irrigation up to May to border row plantation (317.00) and T_8 - 100% irrigation up to May as per requirement i.e. without deficit (306.74). The minimum number of pods plant^{-1} from each flush(188.07) was obtained in the treatment T_1 (i.e. control-I) Rainfed orchard plantation) and it was at par with the treatment T_9, i.e. control-II, Rainfed border row plantation (190.54) and T_2- 100% irrigation up to January as per requirement (192.27).

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_8 (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.

Among irrigation regimes significantly minimum number of fruits plant^{-1} Pod weight, pod length, pod girth and yield plant^{-1}was recorded in the treatment rainfed i.e. Control-I (Rainfed orchard plantation) during both the years and pooled analysis, because under stress condition the relative water content in the leaves was decreased drastically and the stomata remains partially closed which inhibit the entry of carbon dioxide in the leaf tissue ultimately the rate of photosynthesis was reduced and thereby the reproductive organs were not supplied significant amount of photosynthates for their normal growth and development of plant. Bahadurt and Rai (2006) postulated that the vegetables contains a large quantity of water (80-85%), thus their yield and quality suffer rapidly under water stress. Drip irrigation system always maintains crop rhizosphere almost at field capacity, so crop never experiences water stress at any stage. The results are in conformity with Prabhakar and Hebbar (2009) [9], Bhogi *et al.* (2011) [2], Owusu and Annan (2010) [8], Chauhan *et al.* (2013) [3], Raja *et al.* (2013) [11] and Colak *et al.* (2015) [5].

Conclusion

From the pooled data, it can be concluded that, an application of 100% irrigation up to March as per requirement and then 66% irrigation up to May obtained maximum yield as compared to the other levels of irrigation during both the years of investigation. Thus the irrigation level of 100% irrigation upto March with 66% irrigation upto May is optimum irrigation level through drip irrigation for drumstick (cv. Bhagya).

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