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Research Paper

Response of grain amaranth (*Amaranthus hypochondriacus*) to irrigation schedules under sprinkler irrigation

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ABSTRACT

A field experiment was conducted during winter (*rabi*) seasons of 2019–20 and 2020–21 at the Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Banaskantha, Gujarat to study the response of grain amaranth (*Amaranthus hypochondriacs* L.) to irrigation schedules under sprinkler irrigation system. The experiment was conducted in a randomised block design (RBD) comprised of 6 irrigation treatments, viz. I_0, Surface irrigation; I_1, Control (only pre-sowing irrigation); I_2, Sprinkler irrigation at 0.2 IW: CPE; I_3, Sprinkler irrigation at 0.4 IW: CPE; I_4, Sprinkler irrigation at 0.6 IW: CPE; and I_5, Sprinkler irrigation at 0.8 IW:CPE with 4 replications. The results revealed that application of irrigation at IW: CPE ratio of 0.8 had significant effect on plant height, inflorescence length (83.4 cm), grain yield (1,625 kg/ha) and straw yield (7,497 kg/ha) compared with control treatment (surface irrigation). Treatment 0.8 IW: CPE resulted in the 28.15% higher grain yield than the control. The highest water-use efficiency (WUE) (12.8 kg/ha-mm) was achieved by the treatment I_1 (only pre-sowing irrigation). Consumptive use (mm) was found increased with increase in irrigation scheduling from I_0 to I_5. The highest consumptive use of 179.3 mm was recorded under the treatment of 0.8 IW: CPE ratio. Irrigation at 0.8 IW: CPE ratio fetched highest net returns of ₹54,701/ha, with benefit: cost (B:C) ratio 3.06 during both the years in pooled analysis.

Key words: Amaranth, Grain yield, Irrigation, WUE

Grain amaranth (*Amaranthus hypochondriacus* L.) belongs to the family Amaranthaceae. The genus *Amaranthus* includes other species of grain type amaranth, viz. *A. peniculatus* (L.)*, A. cruentus* (L.) and *A. caudatus* (L.). The grain types of amaranthus are thought to be of central American origin. It is a potential upcoming subsidiary food crop, considered by many as crop of the future. Certain attributes, like it's higher productivity potential added with substantial quantities of minerals, carbohydrates, fats and proteins comparable with any of the improved cereals, have aroused great interest in development of grain amaranth as a cultivated crop (Desai *et al.,* 2013). Amaranth is a quick growing multipurpose crop suitable for poor soils of semi-arid and seasonal wet areas. Grain amaranth assumes special significance because of its C4 pathway indicating high productivity.

Water is very precious and scarce input during winter, its efficient utilization is quite necessary. Efficient usage of water for irrigation aims at the utilization of available water resources to the maximum possible advantages in the crop production. Among the several recognized criteria of irrigation scheduling, the climatological approach (IW/CPE ratio) is very useful. More favourable irrigation regimes maintained as per crop need results in higher soil moisture in root zone promoting cellular activity like enlargement, cell expansion and multiplication and creating synergistic impact on water potential of cell and stomatal conductance ultimately on photosynthetic activity (Rana *et al.,* 2019). Soil-moisture stress reduces the rate of photosynthesis and also the rate of translocation of nutrients, which ultimately influences the growth and yield of the crop. The right time of application of adequate amount of irrigation water with minimum losses is essential for efficient and economic utilization of water resources for higher production (Shinde *et al.,* 2014). The area of present experiment is located in arid and semi arid region. In this region water scarcity is a major issue. Due to lack of water now-a-days farmers are looking forward and adopting sprinkler irrigation system but they are unaware about the quantity of water and time

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interval suitable for irrigation schedules. So this experiment is very crucial in finding out proper irrigation scheduling of grain amaranth for getting higher yield and water productivity as compared to conventional methods of irrigation.

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) seasons of 2019–20 and 2020–21 at the Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Banaskantha, Gujarat. The soil of the experimental site was loamy sand, low in organic carbon (0.23%) and available nitrogen (159 kg/ha), medium in available phosphorus (278.9 kg/ha) and available potassium (145.6 kg/ha) having *p*H of 7.54. The treatments comprised of 6 irrigation schedules, viz. I_0, Surface irrigation (5 cm Depth); I_1, Control (only pre-sowing irrigation); I_2, Sprinkler irrigation at 0.2 IW: CPE; I_3, Sprinkler irrigation at 0.4 IW: CPE; I_4, Sprinkler irrigation at 0.6 IW: CPE; and I_5, Sprinkler irrigation at 0.8 IW: CPE taken in randomized block design with four replication. The grain amaranth variety Gujarat Amaranth 2 was sown on November 14, 2019 and November 12, 2020. Gujarat Amaranth 2 variety has red colour inflorescence and leaf, protein content 11.30% and lysine content 4.15%. Its average production is 1,754 kg/ha and maximum is 2,373 kg/ha. It has a maturity period of 98–105 days. The required quantity of clean seeds was mixed with soil by making for uniform sowing of seeds. The sowing was done manually in previously opened furrows at a depth of 2 cm. Seeds were covered properly with the soil. The crop was fertilized with 60–40–00 N-P-K/ha in the form of diammonium phosphate (DAP) and urea commonly to all the plots. Half dose of nitrogen and full dose of phosphorus were applied at the time of sowing; remaining nitrogen was top-dressed after 45 DAS (days after sowing). Recommended package of practices were followed for growing the crop. Irrigation was applied as per treatment based on cumulative pan evaporation (CPE) values. The water was conveyed through open field cannel and measured by Parshall flume. The depth of each irrigation was kept 40 mm under sprinkler irrigation system. The CPE was taken as a sum of daily evaporation from United States Weather Bureau (USWB) class a pan evaporimeter minus the rainfall since the previous irrigation. The crop was harvested from net plot at physiological maturity stage.

RESULTS AND DISCUSSION

Scheduling of irrigation through IW: CPE ratio brought about significant variation in plant stand, plant height, inflorescence length, days to maturity, water use efficiency (WUE), consumptive use of water (CU), grain and straw yields (Table 1-2). Initial plant stand at 30 DAS of amaranth was found to be non-significant due to different irrigation schedules whereas, plant stand at harvest was found significant. Plant stand at harvest was recorded significantly higher in application of irrigation through surface irrigation which was at par with irrigation applied at IW: CPE ratio of 0.8 and 0.6. The amaranth crop irrigated at IW: CPE ratio of 0.8 recorded highest plant height at harvest (190 cm) and at 60 DAS (88.5 cm) which was found at par with IW: CPE ratio of 0.6. The different levels of irrigation on plant height at 30 DAS was found to be non-significant in pooled analysis. In pooled data basis, the inflorescence length was recorded significantly highest in the treatment 0.8 IW: CPE ratio. Days to maturity was affected significantly in application of irrigation at 0.8 IW: CPE ratio which was at par with surface irrigation.

Table 1. Effect of irrigation scheduling on yield attributes and water study of grain amaranth under sprinkler irrigation (Pooled data over 2 years)

Treatment	Plant stand at 30 DAS/ plot	Plant stand at harvest/ plot	Plant height at 30 DAS (cm)	Plant height at 60 DAS (cm)	Plant height at harvest (cm)	Inflore scence length (cm)	Days to maturity	WUE (kg /ha-mm)	Consumptive use (mm)
Irrigation schedules (I)									
I_0 (Surface irrigation)	242	235	25.9	72.0	161.7	66.7	121	8.5	148.6
I_1, (Control, only pre-sowing irrigation)	222	170	24.4	57.9	90.1	39.7	109	12.8	36.5
I_2, (0.2 IW: CPE)	221	193	23.0	61.3	114.3	50.2	114	12.5	58.8
I_3, (0.4 IW: CPE)	222	210	24.9	73.8	144.6	63.6	117	11.5	103.2
I_4, (0.6 IW: CPE)	228	223	24.9	79.9	172.2	72.1	119	9.0	155.0
I_5, (0.8 IW: CPE)	232	228	25.6	88.5	190.0	83.4	121	9.1	179.3
SEm±	4.60	4.51	0.55	3.23	3.59	1.52	0.80	0.35	-
CD (P=0.05)	NS	13.0	NS	11.74	10.35	4.39	2.31	1.01	-

DAS, Days after sowing; WUE, Water use efficiency.

Table 2. Effect of irrigation scheduling on harvest index, yield and economics of grain amaranth under sprinkler irrigation (Pooled data over 2 years)

Treatment	Harvest index (%)	Straw yield (kg/ha)	Grain yield (kg/ha)	Gross income (₹/ha)	Cost of cultivation (₹/ha)	Net income (₹/ha)	Benefit: cost ratio
Irrigation schedules (I)							
I_0, (Surface irrigation)	17.2	6,134	1,268	63,402	24,709	38,693	2.57
I_1, (Control, only pre-sowing irrigation)	16.7	2,330	466	23,287	21,292	1,995	1.09
I_2, (0.2 IW: CPE)	15.6	3,964	731	36,562	22,042	14,520	1.66
I_3, (0.4 IW: CPE)	17.5	5,646	1,192	59,606	23,542	36,064	2.53
I_4, (0.6 IW: CPE)	18.1	6,346	1,391	69,565	25,042	44,523	2.78
I_5, (0.8 IW: CPE)	17.9	7,497	1,625	81,243	26,542	54,701	3.06
SEm±	0.60	314.33	28.65	-	-	-	-
CD (P=0.05)	1.03	1,142.7	82.8	-	-	-	-

Water use efficiency (kg/ha-mm) and consumptive use of water (mm) as influenced by varying scheduling are given in Table 1. The highest WUE (12.8 kg/ha-mm) was achieved by the treatment of only pre-sowing irrigation in pooled analysis. Minimum WUE (8.5 kg/ha-mm) was recorded under the treatment of surface irrigation. Consumptive use (mm) was found increased with increase in irrigation scheduling from I_0 to I_5. The highest consumptive use of 179.3 mm was observed under irrigation applied at IW: CPE ratio of 0.8 in mean data of two years. Harvest index was found significantly higher in treatment I_4 which was at par with I_5. Straw yield was recorded significantly higher in irrigation applied at IW: CPE ratio of 0.8 under sprinkler system

Grain yield was affected due to different irrigation scheduling under sprinkler system. Grain yield was found significantly higher in irrigation applied at 0.8 IW: CPE ratio (1,625 kg/ha) among rest of the treatment. The remarkable increase in yields with higher levels of irrigation might be attributed to favourable effect on yield attributes viz., plant height, inflorescence length and other parameters which might be frequent supply; and optimum amount of soil moisture as plant needed this for plant root system development which in turn improves the soil water intake, nutrient uptake, translocation and metabolic processes in the plant body along with increased photosynthesis process ultimately growth of plant. Our results are in line with findings of Bindhani *et al.,* (2020); Puppala *et al.,* (2021); and Kumar and Dhillon (2023). The significant increase in grain yield was due to favourable effect of increasing irrigation frequency, which may be owing to more conversion of sources to sink for the formation of seed. These results are inconformity with those reported by Bhunia *et al.,* (2005); Sumathi *et al.,* (2007); and Solanki *et al.,* (2016). While the lower grain and stover yields under the lower level of irrigation (0.4 IW/CPE ratio) was owing to lower value of growth and yield component resulted into lesser grain and stover yields. Thus, water deficit in plant inhibits photosynthesis, tends to raise plant temperature, consequently increased respiration process that leads to the breakdown of assimilates (Kramer, 1969).

Economics play an important role in deciding the adoption of particular treatment by the farmers. Successive increase in irrigation regime up to IW: CPE ratio of 0.8 significantly increased the net returns as compared to irrigation at IW: CPE ratio of 0.2, 0.4 and 0.6. The crop irrigated at IW: CPE ratio of 0.8 fetched the highest net returns of ₹54,701 with benefit: cost ratio 3.06 (Table 2)

I_5, Sprinkler irrigation at 0.8 IW: CPE

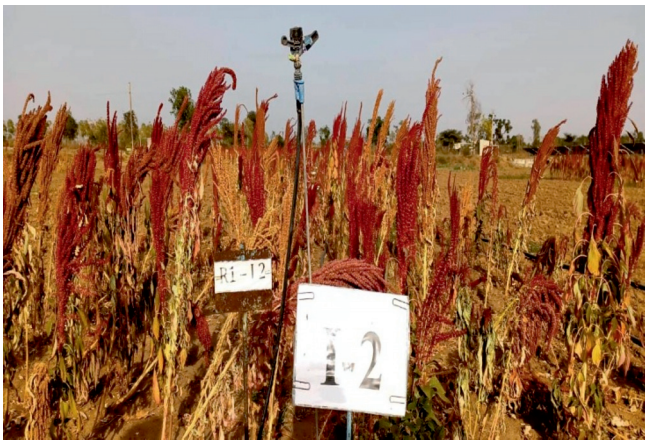
I_4, Sprinkler irrigation at 0.8 IW: CPE

I_5, Sprinkler irrigation at 0.8 IW: CPE

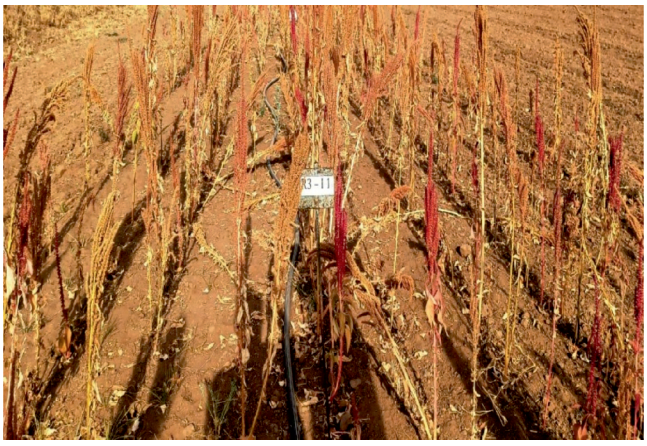
I_4, Sprinkler irrigation at 0.6 IW: CPE

I_0, Surface irrigation (5 cm depth)

I_3, Sprinkler irrigation at 0.4 IW: CPE



I_2, Sprinkler irrigation at 0.2 IW: CPE



I_1, Control (only pre-sowing irrigation)

Treatment effect at Harvest time

while, irrigation applied only at pre sowing irrigation gave minimum (1.09) returns (average of 2 years data). It is concluded that under prevailing agro-climatic condition of north Gujarat, grain amaranth crop should be irrigated at 0.8 IW: CPE ratio under sprinkler irrigation.

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