

FERTIGATION IN GRAIN AMARANTHUS IN NORTH GUJARAT

*¹PARMAR, B. S.; ²PATEL, M. M. AND ³DEORA, B. S.

CENTRE FOR NUTRIENT RESOURCE MANAGEMENT
S. D. AGRICULTURAL UNIVERSITY
SARDARKRUSHINAGAR – 385 506, GUJARAT, INDIA

**EMAIL: parmarbs26@gmail.com*

¹Assistant Professor, CNRM, S.D.Agricultural University, Sardarkrushinagar- 385506, Dist: Banaskantha, Gujarat

² Assistant Professor, ARS, S.D.Agricultural University, Sardarkrushinagar- 385506, Dist: Banaskantha, Gujarat

³ Professor, CNRM, S.D.Agricultural University, Sardarkrushinagar- 385506, Dist: Banaskantha, Gujarat

ABSTRACT

A field experiment was conducted to study the effect of treatments consists of four levels of irrigation i.e. 0.6, 0.8, 1.0 PEF through drip and 1.0 IW/CPE (60 mm depth) as surface irrigation along with three levels of nitrogen i.e. 60%, 80% and 100 % of RDN as fertigation (except surface irrigation). The combinations were tested for three years in loamy sand soil of semi arid conditions of North Gujarat on Amaranthus variety Gujarat Amaranthus 3. Among the irrigation treatments, crop irrigated at 1.0 PEF drip recorded significantly higher yield of Amaranthus over surface method (control) of irrigation. This treatment increased 431 kg/ha of grain yield then surface method (1.0 IW/CPE ratio). However, irrigation at 0.8 PEF (I₂) remained at par with treatment 1.0 PEF (I₃), which saved 17.93 per cent of water over surface method (control) of irrigation. Further, the harvest index was recorded highest (18.7 %) in treatment I₂ (0.8 PEF). The increasing level of nitrogen significantly increased the grain yield of Amaranthus. Application of 100% RDN through fertigation recorded significantly the highest grain yield (1915 kg/ha) over remaining fertigation treatments. The highest net return (51054 kg/ha) and profitability (459.66 kg/ha/day) were recorded under drip irrigation at 1.0 CPE. Likewise, among the fertigation treatments, the highest net return (48677 kg/ha) and profitability (472.59 kg/ha/day) were recorded under 100% fertilization.

KEY WORDS: *Amaranthus, Drip irrigation, Economics, Fertigation*

INTRODUCTION

As the agricultural demand for water underwent an exponential growth in north Gujarat during 1960-1990, there was an explosion of tube wells powered by high capacity pump sets to meet this demand, as surface water supplies were extremely limited. While irrigated agriculture flourished, groundwater draft far exceeded the recharge. In arid and semi arid areas, groundwater is often the only water source, which is available around the year.

Groundwater basins are not resource in itself but long term storage reservoirs (Jeyaram *et al.*, 1992). For their sustainable management, the recharge is the most crucial factor required. Groundwater basins can be viewed as nested systems of recharge and dis-recharge appearing in the form of springs, streams or evapotranspiration (Boonstra and Bhutta, 1996). The understanding of such system is the prerequisite for their management. The situation was on the verge of turning worst

due to alarming rate of water mining or say over exploitation for irrigation in agriculture. Several block of the state of Gujarat were declared as dark zone; of which the maximum numbers of the blocks were in the North Gujarat only. In the circumstances, to check the irrigation water problem, Government of Gujarat established the Gujarat Green Revolution Company (GGRC), a decade back for the effective adoption of Micro Irrigation Systems in the state. The effective implementation of MIS schemes by the company and pro farmer government policies resulted in the increasing awareness and rate of adoption of MIS among the farmers. Therefore, MIS appears to be the ray of hope for the future agriculture in ground water exploited North Gujarat region.

Application of water and soluble nutrients to growing plants through drip irrigation system (fertigation) is an effective method to obtain higher and quality yield along with saving of water and fertilizer. Fertigation involves not only efficient use of two most important inputs like water and nutrients but also ensures their simultaneous availability to plants. India has the largest irrigation network in the world although; its irrigation efficiency has not been more than 40 per cent. Bringing more area under irrigation will largely depend upon efficient use of water. In this context, micro irrigation has most significant role to achieve not only higher productivity and water use efficiency, but also to have sustainability with economic use. In fertigation, nutrient use efficiency could be as high as 90 per cent compared to 40 to 60 per cent in conventional methods (Solaimalai *et al.*, 2005). The amount of fertigation lost through leaching can be as low as 10 per cent in fertigation, whereas it is 50 per cent in the traditional system.

Water and fertilizer productivity can be enhanced through fertigation without any adverse effect on growth and yield. The cost of cultivation of amaranthus is comparatively lower, hence being cultivated in considerable area of North Gujarat. Response of irrigation is better observed (Patel *et al.*, 2005) and hence, farmers generally apply 5 to 6 surface irrigations (60 mm each) besides two irrigations (60 mm, 40 mm) for germination. The experiment was proposed to generate information for fertigation in *Amaranthus*.

MATERIALS AND METHODS

The experiment was conducted during 2011 to 2013 at Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. The experimental soil was light in texture, loamy sand, well drained with 5-6 per cent field capacity, 2-3 per cent PWP and bulk density of 1.65 gm/cc, electrical conductance 0.18 ds/m with pH value of 7.6 to 7.9. The soil have 154 kg/ha, 32 kg/ha and 182 kg/ha of available N, P and K. The study area falls in semi arid conditions of North Gujarat.

The crop was sown in the 2nd fortnight of November during all the years of experimentation. The crop spacing was as per scientific recommendation. The experiment was laid out in split plot design with 4 replications. The treatments were four irrigation schedules viz., I₁: 0.6 PEF, I₂: 0.8 PEF, and I₃: 1.0 PEF.(drip) and 1.0 IW/CPE ratio (surface) in main plot and three levels of fertigation i.e. 60%, 80% and 100 % of RDN (60-40-00) in sub plot. In drip irrigation treatments, the irrigations were applied at alternate day as per scheduled water requirement, while in surface irrigation treatment, it was applied at IW/CPE: 1.0 at 50 mm depth. For obtaining better germination, one surface irrigation of 60 mm was applied as pre sowing, while one light irrigation of 40 mm was applied post

sowing. The fertilizer application scheduling was designed in a way that 30 per cent nitrogen and full dose of phosphorus (40 kg/ha) were applied as basal and remaining nitrogen was applied as per treatments in two equal split at 30 and 45 days after sowing through drip and surface method.

The drip system was laid at 0.9 m lateral (16 mm) and 0.45 m dripper (4 lph) distance. The lateral cocks were provided on lateral for managing treatment wise time of operation. The system was operated at a pressure of 2 kg/cm². The drippers used were originally designed to deliver 4 lph. However, in actual field situation depending upon the field pressure, the quantity of water delivered per dripper at different places were measured and the average values were utilized while working out the volume of water to be delivered and time of operation of the drip system.

The crop was normally harvested manually after 100 days after sowing. Threshing was done manually. The grain and straw yield per year was recorded and converted into hectare basis.

The growth parameters, yield attributes and yield observations were taken and performance parameters such as water use efficiency, production efficiency and relative economics efficiency were estimated as under.

Water use efficiency

The water use efficiency was calculated as,

$$WUE = S_{ye} / W_i \quad \dots\dots\dots(1)$$

Where,

WUE = irrigation water use efficiency,
 kg/ha-mm

S_{ye} = economic seed yield, kg/ha,

W_i = the total depth of water applied
 through irrigation, mm.

Production efficiency

Production efficiency represents the increase in seed yield on a daily basis (Tomar and Tiwari, 1990). It can be

calculated by following mathematical equation,

$$PE = S_{ye} / \Delta n \quad \dots (2)$$

Where,

PE = Production efficiency in kg/ha/day

Δn = duration of crop in days.

Relative economics efficiency

The relative economic efficiency (REE) indicates the profitability enhanced with reference to control treatments. The relative economic efficiency was calculated by using following formula.

$$REE = \Delta N / A \times 100$$

Where,

ΔN = difference of net return from the drip
 irrigation method and surface
 method of irrigation (control)

A = net return from surface method of
 irrigation.

There were no any severe incidence of pests and diseases were observed throughout the crop season. The crop was harvested during the 2nd fortnight of March.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized as under.

Growth characters

The pooled data of three years of growth and yield attributes presented in Table 1 indicated that different treatment had significant effect on growth and yield attributes viz., plant height, inflorescence length, days to 50 % flowering and days to maturity. Among the irrigation schedules, crop irrigated at 1.0 PEF through drip recorded significantly the highest value of plant height (165.8 cm) and inflorescence length (80.3). Similarly, the effect of irrigation schedules was observed significant with respect to days to 50 % flowering and days to maturity. Due to frequent irrigation at 1.0 PEF through drip, the days to 50 % flowering and maturity days were lengthen. Increase in plant height and inflorescence length at 1.0 PEF was mainly due to

frequent irrigation and more availability of water through the crop season in root zone and thus, no water stress occurred. The results are in the line with the findings of Sheng *et al.* (2011). Among the fertilizing treatment, application of 100% RDN through drip recorded significantly the higher plant height (165.0 cm) as compared to other treatment, but it remained at par with 80% RDN. In case of inflorescence length, it was significantly the longest under 100% RDN.

Effect of irrigation and fertigation on grain yield

The pooled results presented in Table 2 indicated that different treatments of irrigation schedules had significant effect on grain yield of *Amaranthus*. Application of irrigation at 1.0 PEF through drip recorded significantly the higher grain yield (2012 kg/ha) then rest of the irrigation treatments, but it remained at par with treatment 0.8 PEF through drip system. The increased grain yield due to drip irrigation might be due to continuous maintenance of moisture level at field capacity around root zone resulted longest inflorescence at 1.0 PEF through drip system. This treatment increased 431 kg/ha higher grain yield then surface method at 1.0 IW/CPE ratio. It was 27.26 per cent higher over 0.6 PEF and control treatment (1.0 IW/CPE ratio).

The increasing level of nitrogen significantly increased the grain yield of *Amaranthus*. The grain yield of *Amaranthus* presented in Table 2 indicated that different treatment of RDN had significant effect on grain yield of *Amaranthus*. The increasing level of nitrogen significantly increased the grain yield of *Amaranthus*. Application of 100% RDN recorded significantly the highest grain yield (1915 kg/ha). The grain yield of *Amaranthus* significantly increased with increasing levels of nitrogen. The increase in grain yield of *Amaranthus* with 100% RDN was ascribed to the combine

effect of nitrogen on improving inflorescence length. The results are in the line with the results obtained by Patel *et al.* (2005).

Water use efficiency

The mean water use was as per the designed irrigation treatments. However, total mean water applied was almost same in both control (surface 1.0 IW/CPE ratio) as well as in best performing treatment (1.0 PEF). However, the water use efficiency was the lowest (3.29 kg/ha-mm) in control, while it was 4.15 kg/ha-mm in 1.0 PEF. Water applied at 1.0 PEF and 0.8 PEF were at par with each one with regards to grain yield and 0.8 PEF treatment saved 17.93 per cent of water over control with 4.62 kg/ha mm WUE. The maximum water use efficiency (4.89 kg/ha mm) was recorded 4.89 kg/ha mm in under 0.6 PEF treatments respectively (Table 3.). Similar results were also reported by Abdelraouf *et al.* (2013).

The response of increasing levels of nitrogen through drip was linear in grain yield (Table 4). The grain yield was increased with corresponding nitrogen increase. The highest grain yield was obtained with 100 % RDN. Although, the maximum nitrogen use efficiency of 45.42 gram/kg N was noted with application of 60% RDN followed by 80 % RDN..

Production efficiency

Relatively the maximum production efficiency (19.53 kg/ha/day) was observed under 1.0 CPE through drip irrigation followed by 0.8 and 0.6 CPE through drip irrigation (Table 6). The lowest production efficiency was recorded under surface irrigation method. Similarly the maximum production efficiency (18.59 kg/ha/day) was observed under 100 % RDN through drip irrigation followed by 80 % and 60% RDN through drip irrigation. It might be due to lower nitrogen levels in the soil. Hence, supplement of sufficient nitrogen significantly enhanced the yield.

It might be due to proper water management through micro irrigation helps the crop in quick utilization of the readily available nutrients resulting in higher growth and dry matter accumulation which increases the per day productivity. The higher assimilation of metabolizable Carbon and N in crop plants due to micro irrigation increased above ground dry matter in addition to increasing root biomass and root absorption surfaces might have increased the production efficiency. Similar results were also obtained by Dhawan (2002) and Namara *et al.* (2007).

Economics

Although, the lowest net seasonal cost was recorded under control treatment due to absence of the drip system cost. Other cost component except, irrigation cost were almost same in both types of drip and surface method of irrigation. The Economics of different treatment worked out on the basis of input cost and harvest price of grain yield which indicated that the maximum net profit of Rs. 51054 /ha was recorded under 1.0 PEF I₃ treatment due to higher yield obtained in the treatment (Table 5). In case of benefit cost ratio, surface irrigation treatment recorded the highest BCR value (1.76) followed by 1.0 PEF (1.73) through drip.

As far as fertilizer levels are concerned, economics of different treatments revealed that the maximum value of net profit Rs./ha. (Rs. 48677) and benefit cost ratio (1.74) were recorded in application of 100% RDN. That is due to use of traditional nitrogenous fertilizers such as urea. The levels of phosphorus fertilizers were same in all the treatments and were applied as basal.

Economics was worked out in terms of the net return, production efficiency, profitability and relative economic efficiency. The highest net return (51054 kg/ha) and profitability (459.66

kg/ha/day) were recorded under drip irrigation at 1.0 CPE. It was due to increment in yields under drip irrigation method. The yield increased due to frequent supply of water through drip irrigation which make plant nutrient easily available. Enhanced water availability increases seed and root N along with the N harvest index, consequently the yield was greater under high moisture availability (1.0 CPE: 2012 kg/ha) than surface irrigation treatment with similar levels of water application (1581 kg/ha) (Gan *et al.*, 2010). The pattern of plant N accumulation, mineralization and utilization in plants are influenced by water availability and uptake (Campbell *et al.*, 2008). Hence, sufficient moisture availability improved seed yield of *Amaranthus*. Similarly, REE was highest in 1.0 CPE with drip than rest of the drip irrigation treatments. In drip irrigation treatments, CBR is lower than control due to involvement of drip system cost.

CONCLUSION

Grain *Amaranthus* is popular cereal crop of North Gujarat which requires comparatively less input costs. Irrigation water being scarce resource in the region; adoption of drip irrigation is getting momentum. The application of water and nitrogen fertilizers through drip system of irrigation resulted in beneficial in terms of water saving and economic returns. Application of irrigation at 1.0 PEF through drip recorded significantly the higher grain yield (2012 kg/ ha), higher net profit (Rs. 51054/ha), the maximum production efficiency (19.53 kg/ha/day) and the highest REE (26.54%) then the rest of the irrigation treatments. However, the grain yield of the treatment 1.0 PEF remained at par with treatment 0.8 PEF through drip system which resulted in 17.93 per cent in water saving. The increasing level of nitrogen significantly increased the grain yield of *Amaranthus*. Application of 100 % RDN

recorded significantly the highest grain yield (1915 kg/ha). The economics of different fertilizer treatments revealed that the maximum value of net profit/ha. (Rs 48677) and benefit cost ratio (1.74) were recorded in application of 100% RDN.

REFERENCES

- Abdelraouf, R. E.; El-Habbasha, S. F.; Taha, M. H. and Refaie, K. M. (2013) Effect of irrigation water requirements and fertigation levels on growth, yield and water use efficiency in wheat. *Middle East Journal of Scientific Research, IDOSI Publications, Dubai Arab Emirates*, **16**(4): 441-450.
- Boonstra, J. and Bhutta, M. N. (1996). Groundwater recharge in irrigated agriculture: the theory and practice of inverse modeling. *J. Hydrol.*, **174**: 357-374.
- Campbell, C.; Zentner, R.; Basnyat, P.; De Jong, R.; Lemke, R. and Desjardins, R. (2008). Nitrogen mineralization under summer fallow and continuous wheat in the semi arid Canadian prairie. *Can. J. Soil Sci.*, **88**(5): 681-696.
- Dhawan, D. B. (2002). Technological change in irrigated agriculture: a study of water saving methods. Commonwealth Publishers, New Delhi.
- Gan, Y.; Campbell, C. A.; Henry, H. J.; Reynald, L. L., Basnyat, P. and McDonald, C. L. (2010). Nitrogen accumulation in plant tissues and roots and N mineralization under oilseeds, pulses, and spring wheat. *Plant Soil*. **332**: 451:461.
- Jeyaram, A.; Faruqui, S. A.; Ravale, R. L. and Sinha, A. K. (1992). Groundwater investigations using LISS-II data in Nagpur district. *Natural Resource Management*, pp. 459-464.
- Namara, R. E.; Nagar, R. K. and Upadhyay, B. (2007). Economics, adoption determinants, and impact of micro irrigation technologies: empirical results from India, *Irrig. Sci.*, **25**: 283-297.
- Patel, B. M.; Ravindrababu, Y.; Patel, P. G. and Patel, M. (2005). Effect of organic and inorganic fertilizers on grain amaranth (*Amaranthus hypochondriacus* L.) varieties. *J. Soils Crops*, **15**(2); 260-263.
- Shenge, H., Liu, Y., Zhang, L. and Zhijian, G. (2011) Study on wheat and fertilizer coupling of drip irrigation spring wheat. *Xinji and Agricultural Sciences, Editorial Department of Xinjiang Agricultural Sciences, Urumqi, China*, **48**(12): 2299-2303.
- Solaimalai, A.; Baskar, M.; Sadasakthi, A. and Subburamu, K. (2005). Fertigation in high value crops. *Agric. Rev.*, **26**(1): 1-13.
- Tomar, S. and Tiwari, A. S. (1994). Production and economics of different crop sequences. *Indian J. Agron.*, **35**(1/2): 30-35.

Table 1: Growth and yield attributes of *Amaranthus* as influenced by various irrigation levels and fertilizer doses (Pooled data of 3 years)

Treatments	Plant Height (cm)	Days to 50 % Flowering	Inflorescence Length (cm)	Maturity Days	Grain Yield (kg/ha)	Straw Yield (kg/ha)	Harvest Index (%)
A. Main plot (Irrigation)							
I ₁ : 0.6PEF	156.2	57	74.2	100	1615	7804	17.10
I ₂ : 0.8 PEF	159.5	59	77.1	102	<u>1881</u>	8179	18.70
I ₃ : 1.0 PEF	<u>165.8</u>	<u>61</u>	<u>80.2</u>	<u>103</u>	<u>2012</u>	<u>9081</u>	18.01
I ₄ :1.0 IW/CPE (50 mm depth)	154.3	57	72.4	99	1581	7845	16.8
S.Em. ±	1.1	0.216	0.6	0.26	47.5	267.8	-
C.D at 5%	3.1	0.605	1.8	0.73	152	856.8	-
CV %	4.8	2.54	6.1	1.78	7.59	10.3	-
B. Sub plot (Fertilizer)							
N ₁ : 60% RDN	153.2	57	71.8	98	1635	7705	17.50
N ₂ : 80% RDN	<u>158.6</u>	59	75.8	101	1766	8018	18.00
N ₃ : 100% RDN	<u>165.0</u>	61	80.4	<u>103</u>	<u>1915</u>	<u>8960</u>	17.60
S.Em. ±	2.0	57	1.0	0.22	19.42	210.4	-
C.D at 5%	7.2	0.18	3.6	0.63	54	728	-
CV %	4.8	0.52	6.1	1.78	7.59	10.3	-
I x N	NS	S	NS	S	NS	NS	-
Y x I x N	NS	NS	NS	NS	NS	NS	-

Table 2: Year wise yield of *Amaranthus* under different treatments

Treatments	<i>Amaranthus</i> Yield (kg/ha)			
	2011-12	2012-13	2013-14	Pooled
A. Main plot (Irrigation)				
I ₁ : 0.6 PEF	1746	1489	1610	1615
I ₂ : 0.8 PEF	1854	1835	<u>1953</u>	<u>1881</u>
I ₃ : 1.0 PEF	<u>2063</u>	<u>1959</u>	<u>2015</u>	<u>2012</u>
I ₄ :1.0 IW/CPE (50 mm depth)	1768	1425	1551	1581
S.Em. ±	49.5	30.4	33.8	47.5
C.D at 5%	143	88	98	152
CV %	9.24	6.30	6.57	7.59
B. Sub plot (Fertilizer)				
N ₁ : 60% RDN	1768	1506	1631	1635
N ₂ : 80% RDN	1834	1678	1787	1766
N ₃ : 100% RDN	<u>1972</u>	<u>1846</u>	<u>1928</u>	<u>1915</u>
S.Em. ±	42.9	26.3	29.2	19.42
C.D at 5%	124	75	85	54
CV %	9.24	6.30	6.57	7.59
I x N	NS	NS	NS	NS
Y X I x N	-	-	-	NS

Table 3: Effect of different irrigation treatment on *Amaranthus* yield, water use efficiency and water saving (Pooled results)

Treatment	<i>Amaranthus</i> Grain Yield (kg/ha)	Water Applied (mm)	Water Use Efficiency (kg/ha-mm)	Saving in Water over Control (%)	Increase in Yield over Control (%)
I ₁ : 0.6 PEF	1615	330	4.89	45.78	6.32
I ₂ : 0.8 PEF	<u>1881</u>	407	4.62	17.93	18.97
I ₃ : 1.0 PEF	<u>2012</u>	485	4.15	-	27.26
I ₄ : 1.0 IW/CPE ratio (Control)	1581	481	3.29	-	-

Table 4: Effect of different fertilizer treatment on *Amaranthus* yield, fertilizer applied, NUE and fertilizer saving (Pooled results)

Treatment	<i>Amaranthus</i> Yield (kg/ha)	Nitrogen Applied (kg/ha)	Nitrogen Use Efficiency (gram/kg N)
N ₁ : 60 % RDN	1682	36	45.42
N ₂ : 80 % RDN	1852	48	36.79
N ₃ : 100 % RDN	2023	60	31.92

Table 5: Economics of different treatments

Treatment	<i>Amaranthus</i> Yield (kg/ha)	Gross Income (Rs./ha)	Seasonal Cost (Rs./ha)	Net Profit (Rs./ha)	BCR
Drip irrigation					
I ₁ : 0.6 PEF	1615	64600	27626	36974	1.34
I ₂ : 0.8 PEF	<u>1881</u>	75240	28526	46714	1.64
I ₃ : 1.0 PEF	<u>2012</u>	<u>80480</u>	29426	<u>51054</u>	<u>1.73</u>
I ₄ : Control (1.0 IW/CPE -60 mm)	1581	63240	22896	40344	1.76
Fertilizer level					
N ₁ : 60 %RDN	1682	65400	26315	39085	1.49
N ₂ : 80% RDN	1852	70640	27119	43521	1.60
N ₃ : 100% RDN	2023	<u>76600</u>	27923	<u>48677</u>	<u>1.74</u>

Selling price: *Amaranthus* Rs. 40.00 per kg

Table 6: Performance parameters of irrigation and fertigation treatments

Treatment	Amaranthus Yield (kg/ha)	Gross Income (Rs./ha)	Production Efficiency (kg/ha/day)	Profitability (Rs/ha/day)	Relative Economic Efficiency (%)
Drip irrigation					
I ₁ : 0.6 PEF	1615	64600	16.15	369.74	- 8.33
I ₂ : 0.8 PEF	1881	75240	18.44	457.98	15.78
I ₃ : 1.0 PEF	2012	80480	19.53	495.66	<u>26.54</u>
I ₄ : Control (1.0 IW/CPE-60 mm)	1581	63240	15.93	407.51	
Fertilizer level					
N ₁ : 60 %RDN	1682	65400	16.68	398.82	
N ₂ : 80% RDN	1852	70640	17.48	430.90	
N ₃ : 100% RDN	2023	76600	18.59	472.59	

Selling price: Amaranthus Rs. 40.00 per kg