

Original Research Article

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Quality Blooming of Marigold in Hydroponics

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ABSTRACT

An experiment to investigate “Quality flower production of Marigold in hydroponics” was conducted at Assam Agricultural University, Department of Horticulture. The experiment was laid out completely randomized design with two factor and three replications. In the experiment marigold plants were grown in five different hydroponic systems (NFT, Water Culture, Aggregate systems with Sand, Cocopeat and Sawdust as potting media) with three different level of hydroponic nutrient solution (EC 1.0 dS/m, EC,1.5 dS/m and EC 2.0 dS/m). Experimental results showed that the system, nutrient solution and their interaction significantly affected the flower quality and production. Among the systems, NFT was found significantly superior to all other systems in terms of quality flower production. Among the nutrients, early emergence of bud and flower was noticed in EC 2.0 dS/m, whereas other flower characters were found to be significantly better in EC 1.5 dS/m. Thus, from the floriculture perspective conclusion can be drawn that treatment combination of NFT and EC 1.5 dS/m is optimum for quality flower production of marigold.

Keywords

EC, Flower, Hydroponics, Marigold, NFT, Nutrient

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Introduction

Hydroponic culture can be regarded as the most intensive method of crop production in modern agricultural industry (Jensen, 2008). Etymologically “Hydroponic” originates from two Greek words; “hydro” means “water” and “ponos” means “labour”. Thus, hydroponic means working with water or investing one’s labour in water. Due to rapid urbanization and industrialization, arable land under cultivation is going to decrease day by day. Besides, poor

soil fertility in some of the cultivable areas, added nutrients through commercial fertilizers has attained a saturation level and productivity is not increasing further with increased level of fertilizer application.

On the other side, there are less chances of natural soil fertility build-up by microbes due to continuous cultivation, frequent drought conditions and unpredictability of climate along with weather patterns, rise in temperature, river pollution, poor water

management, wastage of huge amount of water and declining ground water level etc. which is alarmingly threatening the production under conventional soil-based agriculture. Under such circumstances, in near future it will be impossible to meet the demand of the entire population solely depending upon open field system of agricultural production. With the progressive demand of cut flowers and having a higher potential per unit area than other crops, commercial floriculture become a choice of many modern progressive farmers.

From the last two decades, floriculture has been rapidly expanding with the propagation of hi-tech production systems under controlled climatic conditions. Hence, in such practices, to minimize the constrains like limited land and water availability, high rate of infection by the soil-borne pathogens, a new practice of growing plant on highly oxygenated nutrient enriched water rather than soil has been evolved which is termed as hydroponics. Marigolds are hardy, annual plants with fine blooming for cheering up any garden. Due to the high demand, its production is needed to be boosted and properly scheduled in staggered manner.

In such pre-planned or programmed blooming, hydroponic helps us to achieve synchronous faster blooming in a batch than soil grown open field cultures. Marigolds are susceptible to diseases caused by soil borne pathogen such as fungal wilt by *Fusarium sp.*, leaf spot by *Alternaria sp.* and bacterial wilts caused by *Ralstonia sp.* Hydroponic culture shows less or almost non-occurrence of soil borne diseases and pathogens. The time, labour and money spend in the process of soil decontamination, bed preparation, fertilization, use of pesticides, weeding and supplying of water are well saved in hydroponic cultures. Hydroponic culture can yield excellent results within a short span of

time with proper knowledge and technique conquering the scarcity of arable soil and water and minimising the environmental hazards caused by excessive uses of toxic insecticides and pesticides.

However, utilisation of hydroponic systems for the commercial production of crops in India and most other developing countries are very limited. Most of the earlier hydroponic researches were confined to leafy vegetables, peppers and tomatoes (Arias *et al.*, 2000; Gruda, 2009; Koyama *et al.*, 2013, Buchanan and Omaye, 2013). Till date little research on floricultural crops has been conducted within hydroponic system. Successful and profitable production of cut flowers can be facilitated through hydroponic culture. So, there is immense potentiality lies in research of hydroponic flowers.

Materials and Methods

An investigation was carried out at Department of Horticulture, Assam Agricultural University, Jorhat to find out the best hydroponic system, EC of hydroponic nutrient solution and growing media for quality marigold flower production. The experiment was laid out in two factor completely randomized design.

Five different levels of hydroponic systems viz., S1 (NFT or Nutrient Film technique), S2 (Water culture system), S3 (Aggregate or drip system with coco peat), S4 (Aggregate or drip system with sand), S5 (Aggregate or drip system with sawdust) and three different levels of hydroponic nutrient solution concentration viz. N1 (EC 1.0 dS/m), N2 (EC 1.5 dS/m), N3 (EC 2.0 dS/m) were taken under the experiment. Thus there were 15 treatment combinations with three replications for each treatment and one control (soil and water). Marigold Inca hybrid was taken for the study. Nursery grown

seedlings at the age of 15 days were transplanted to the hydroponic systems. NFT systems were constructed with locally available low cost materials. For water culture system, thermocol boxes with lids were used. For both of the NFT and water culture system, plants were planted in 5 inch hydroponic net pots and for aggregate system 12 inch plastic pots were used for planting.

A stock nutrient solution was formulated dissolving different inorganic salts at different concentration in order to meet the nutrient demand of Marigold and diluted to the required EC levels during application. Regular monitoring of EC and pH of the nutrient solution was done by portable EC meter and pH meter and adjusted accordingly. The yield and quality parameters were recorded at different stages of crop growth. Data were statistically analysed by student t-test for comparison of means using Microsoft Excel for significance ($p \leq 0.05$).

Results and Discussion

The study revealed that the yield and quality parameters *viz.*, number of flowers per plant, weight of flower (g), diameter of fully opened flower (cm), Appearance of first flower bud (days), Duration of flowering (days) were significantly influenced by different hydroponic systems and hydroponic nutrient solution concentrations (Table 1).

Appearance of first floral bud

It is apparent from the data that appearance of first floral bud was significantly affected by different systems. Earliest emergence of floral bud was recorded in NFT system (S1) (30.89 days) and the longest time period required for flower bud initiation was noticed in sawdust (S5) (48.00 days). Different EC levels statistically exerted significant effect on the appearance of first floral bud in marigold. the

flower bud initiation was earliest (37.47 days) in the plants grown in EC 2.0 dS/m (N3) solution and maximum days (43.07 days) required for flower bud appearance was recorded in EC 1.0 dS/m (N1). The data presented in table 1 reveal that the interaction effect of system and EC in terms of appearance of first floral bud was statistically significant.

Earliest emergence of bud (27.00 days) was seen in combination of NFT system (S1) and EC 2.0 dS/m (N3) and maximum days (49.00 days) required for bud emergence was recorded in sawdust (S5) and EC 1.0 dS/m (N1). Among the media, sand (S4) recorded earliness of floral bud emergence (44.11 days after transplanting). However, sawdust recorded the maximum (48.00 days after transplanting) duration of floral bud emergence in marigold. Comparison of control (C0) with other treatments revealed significant difference.

Appearance of first floral bud was found in control (C0) at 46.33 days after transplanting. Early emergence of floral bud recorded in NFT system (S1) and EC 2.0 dS/m (N3) might be due to the higher nutrient concentration. Early initiation of buds can be due to fast nutrient absorption and simultaneous transportation of growth stimulating substances such as cytokine in to the axillary buds, resulting in inhibition of apical dominance. This resulted in a better sink for faster photosynthetic mobilization and early transformation of plant parts from vegetative to reproductive stage. References suggest that there are evidences of positive effects of high concentrations of nutrient solution. In *Salvia*, the rise in Hoagland concentration at 200 per cent resulted flowering of plants 8 days earlier than the plants in lower concentrations and also increasing total dry weight and leaf area (Kang and Van Iersel, 2004).

Duration of flowering (days)

Significant effect of the treatment combinations on duration of flowering were observed in the analysed experimental data. In between the systems, NFT system (S1) recorded maximum duration of flowering (35.89 days) and sawdust (S5) recorded minimum duration of flowering (28.44 days). Among the nutrients, maximum flowering duration (36.33 days) was recorded in EC 1.5 dS/m (N3) followed by (33.33 days) EC 2.0 dS/m (N2) and 30.53 days in EC 1.0 dS/m (N1).

The interaction effects of systems and EC were significant and maximum flowering duration (41.67 days) was recorded in NFT system (S1) and EC 1.5 dS/m (N2) and minimum duration of flowering (27.33 days) was recorded sawdust (S5) and EC 1.0 dS/m (N1). Among the media tested, sand (S4) recorded maximum flowering duration (34.22 days) which was statistically at par (33.89 days) with cocopeat (S3). However, sawdust (S5) recorded the minimum (28.44 days) duration of flowering. The statistical comparison of control (C0) (control) with other treatment combinations were found to be highly significant.

Control (C0) was found to be inferior to all other treatment combinations in terms of flowering duration (26.67 days). For marigold grown in all systems, the duration of flowering were shown to increase with an increase in the solution concentration up to an EC of 1.5 dS/m.

This can be explained by the insufficient availability of nutrients at EC as low as 1.0 dS/m. Sonneveld (1989) reported that the fertilizer solution at lower ECs have lesser nutrients which might induce nutrient deficiency in the plants. Limited irrigation or increased salt concentrations in the nutrient

solution have affected photosynthesis, transpiration, and stomatal conductance under elevated EC (Romero Aranda *et al.*, 2001). The reproductive parts of plant formed from the resources stored in the plants during the growth period of the plant.

Thus any treatment that influence on the growth characters will ultimately influence upon the flowering characters of the plant. Continuous supply of nutrient foster the formation of photosynthates and supply of assimilates to the reproductive sink which in turn helped the plants to produce higher flower yield with maximum duration of flowering.

Flowers per plant

The data in respect of flower per plant are presented in Table 1 shows statistically significant differences. Among the systems, maximum flowers per plant (23.56) were recorded in NFT system (S1) and minimum was recorded in sawdust (S5) (14.00). Among the EC levels, EC 1.5 dS/m (N2) resulted in maximum number of flowers per plant (20.13) and minimum flowers (17.33) per plant was recorded in EC 1.0 dS/m (N1). Interaction effect between system and different level of EC showed significant variation in terms of flowers per plant.

The maximum flower number (26.33) was recorded in NFT system (S1) and EC 1.5 dS/m (N2) and the minimum (13.67) was recorded in sawdust (S5) and EC 1.0 dS/m (N1). Comparison of different media had shown sand (S4) as best (18.67) media and sawdust (S5) as inferior (14.00) media in respect to flower per plant in marigold.

The statistical comparison of control (C0) (control) with other treatment combinations were found to be highly significant. Control (C0) was found to be inferior to all other

treatment combinations in terms of flowers per plant (11.33). Increase in numbers of flowers per plant might be due to the availability of nitrogen and phosphorus in adequate amount which helped in generation of more primary branches resulting more flower bud and flower appearance. Chiariello and Gulman (1991) reported that, since reproductive organs are constructed from resources either recently acquired or previously acquired by the vegetative parts, any factor affecting vegetative parts will ultimately affect reproductive yield.

On the contrary, Johnson G (2010) mentioned that excessive vegetative growth commonly occurs when plants are grown under high fertility conditions and are being heavily watered. Under these conditions, flowering and fruiting is delayed as plants continue to put on new growth. This was supported by the finding of present experiment.

Flower diameter (cm)

Among the systems, NFT system (S1) (8.28 cm) was found to be best for maximum flower diameter and minimum flower diameter was recorded in sawdust (S5) (6.33 cm). The nutrient at EC 1.5 dS/m (N2) produced maximum diameter of flower (7.96 cm) which was statistically at par with EC 2.0 dS/m (N3) (7.87 cm). Minimum flower diameter (6.93 cm) was recorded in EC 1.0 dS/m (N1). Interaction effect showed significant variation in terms of flowers diameter. The maximum flower diameter (8.93 cm) was recorded in treatment combination NFT system (S1) and EC 1.5 dS/m (N2) and the minimum flower diameter (5.63 cm) was recorded in sawdust (S5) and EC 1.0 dS/m (N1). Comparison of different media presented sand (S4) (7.68 cm) as best media which was at par with cocopeat (S3) (7.66 cm) and NFT system (S1) (6.33 cm) as inferior media in respect to flower diameter in

marigold. The statistical comparison of control (C0) (control) with other treatment combinations were found to be highly significant. Control (C0) was found to be inferior to all other treatment combinations in terms of flower diameter (5.70 cm). The result found was on account of available nutrient and growing conditions to increase amino acids synthesis, chlorophyll formation, and better carbohydrate transformation, which in turn resulted into better growth of flower. The present results are in harmony with the findings of Datta (2000).

The NFT hydroponic system was an effective and reliable method for feeding the plant roots with nutrient, water and oxygen, leading to reduced nutrient losses during the experiment and low plant nutrient requirements. This conclusion is in line with many studies on anthurium, gerbera and geranium which revealed that plants can absorb ions at very low concentrations when nutrient solutions are continuously applied (Dufour and Guerin, 2005; Zheng *et al.*, 2005; Rouhpael and Colla, 2009).

Among the media tested, sand and cocopeat has shown similar performance in terms of flower diameter. This might be due to the water holding capacity and higher cation exchange capacity of cocopeat which in turn helped the plant with adequate supply of nutrient and water whereas sand had excellent capillary action, which results in lateral movement of nutrients so that there is an even distribution of nutrients throughout the root zone. Additionally, water retention is high owing to the smallness of the sand particles, allowing less irrigation. Further the coarse particles of the sand used in this experiment provided better aeration to the root. Anchorage of the plants in sand was also better due to weight of sand particle as compared to other media.

Table.1 Yield and quality of Marigold as influenced by different hydroponic systems and hydroponic nutrient solution concentrations

Treatment	Appearance of first floral bud				Flowers per plant				Flower diameter (cm)				Duration of flowering				Fresh weight of flower			
	EC 1.0 dS/m (N ₁)	EC 1.5 dS/m (N ₂)	EC 2.0 dS/m (N ₃)	Mean	EC 1.0 dS/m (N ₁)	EC 1.5 dS/m (N ₂)	EC 2.0 dS/m (N ₃)	Mean	EC 1.0 dS/m (N ₁)	EC 1.5 dS/m (N ₂)	EC 2.0 dS/m (N ₃)	Mean	EC 1.0 dS/m (N ₁)	EC 1.5 dS/m (N ₂)	EC 2.0 dS/m (N ₃)	Mean	EC 1.0 dS/m (N ₁)	EC 1.5 dS/m (N ₂)	EC 2.0 dS/m (N ₃)	Mean
NFT (S ₁)	35.00	30.67	27.00	30.89	20.67	26.33	23.67	23.56	7.23	8.93	8.67	8.28	30.67	41.67	35.33	35.89	16.24	21.82	17.92	18.66
Water culture (S ₂) (Water culture)	36.33	32.67	28.67	32.56	20.00	21.00	20.67	20.56	6.90	8.60	8.43	7.98	30.33	40.33	35.67	35.44	16.12	20.66	18.11	18.30
Cocopeat (S ₃) (Cocopet)	48.33	46.33	43.67	46.11	15.67	18.33	17.00	17.00	7.47	7.83	7.67	7.66	31.67	35.33	34.67	33.89	17.25	18.09	17.71	17.68
Sand (S ₄)	46.67	44.33	41.33	44.11	16.67	20.67	18.67	18.67	7.40	7.63	8.00	7.68	32.67	35.67	34.33	34.22	17.09	17.63	18.48	17.73
Sawdust (S ₅) (Sawdust)	49.00	48.33	46.67	48.00	13.67	14.33	14.00	14.00	5.63	6.33	7.03	6.33	27.33	28.67	29.33	28.44	13.01	14.63	16.24	14.63
Mean	43.07	40.47	37.47	40.33	17.33	20.13	18.80	18.76	6.93	7.87	7.96	7.58	30.53	36.33	33.87	33.58	15.94	18.57	17.69	17.40
Control (C ₀) (Control)				46.33				11.33				5.70				26.67				13.17
	SE.d (±)		C.D. (5%)		SE.d (±)		C.D. (5%)		SE.d (±)		C.D. (5%)		SE.d (±)		C.D. (5%)		SE.d (±)		C.D. (5%)	
Control vs. rest	0.90		1.83		0.98		1.99		0.18		0.36		0.47		0.96		1.48		3.01	
Nutrient (N)	0.44		0.90		0.57		1.16		0.10		0.21		0.27		0.56		0.88		1.80	
System (S)	0.34		0.69		0.44		0.90		0.08		0.16		0.21		0.43		0.68		1.39	
Interaction (SxN)	0.76		1.55		0.98		2.00		0.17		0.36		0.47		0.96		1.52		NS	

Fresh weight of flowers

Maximum fresh weight of the flower was recorded in NFT system (S1) (18.66 g) which was at par (18.30 g) with water culture system (S2) and minimum was recorded in sawdust (S5) (14.63 g). It is obvious from the data analyzed that different EC produced significant effect on flower fresh weight. Maximum fresh weight (18.57 g) of flower was recorded in EC 1.5 dS/m (N2) which was at par with EC 2.0 dS/m (N3) (17.69 g). Minimum fresh weight (15.94 g) of flower was recorded in EC 1.0 dS/m (N1). The interaction effects of hydroponic systems and nutrient concentration were statistically not significant.

Among the media under study, sand (S4) recorded highest fresh weight of flower (17.73 g) which was at par (17.68 g) with cocopeat (S3) and minimum flower fresh weight (14.63 g) was recorded in sawdust (S5). The statistical comparison of control (C0) (control) with other treatment combinations were found to be highly significant. control (C0) was found to be inferior to all other treatment combinations in terms of flower fresh weight (13.17g). Maximum fresh weight of flower was recorded in NFT and EC 1.5 dS/m. This might be attributed to the optimum availability and uptake of nutrients and water, enhancing the development in terms of vegetative and reproductive growth with more assimilation of photosynthates towards sink and thereby increase the fresh weight of flower and ultimately improving flower quality.

Among the media tested, sand and cocopeat has shown similar performance in terms of bud fresh weight of flower. This might be due to the water holding capacity and higher cation exchange capacity of cocopeat which in turn helped the plant with adequate supply

of nutrient and water enhancing growth and flowering. This result is in conformity with Le Quoc Dien (2003) who found maximum flowers fresh weight in gerbera when the plants were grown under coco peat medium.

Lateral movements of nutrients due to the excellent capillary action of sand had made an even distribution of nutrients throughout the root zone. Additionally due to the size of sand particles used in this experiment, optimum water retention was also observed which resulted better growth and flowering in marigold. Conformity of this finding was found with Moraghebi and Mohebbi (2011) in which they had suggested the use of sand as a media finding no significant difference between perlite and sand in production of tuberose.

Based on the findings of the present investigation, it can be concluded that for quality flower production of NFT system was the best system. Among different levels of EC, marigold showed the best response in EC 1.5 dS/m. Among different media used in aggregate technique, marigold showed best response in sand whereas sawdust has shown very poor result and it was at par with the control in most of the observations. Overall, sawdust was recorded with the inferior response in comparison to all other systems.

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