The Pharma Innovation Journal 2023; 12(7): 2412-2416

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 2412-2416

www.thepharmajournal.com
Received: 03-05-2023
Accepted: 13-06-2023

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Effect of different agricultural wastes as growing substrates on growth and flowering responses of *Gaillardia pulchella* Foug

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Abstract
Organic waste from agriculture can be properly managed by reusing it for environmental management and as a source of plant nutrients. In view of this, the present study entitled "Effect of Different Agricultural Wastes as Growing Substrates on Growth and Flowering Responses of *Gaillardia pulchella* Foug," was conducted at Horticultural Research cum Instructional Farm at College of Agriculture, IGKV, Raipur (C.G.) during the academic year 2022-23. The experiment was laid out in completely randomized block design using eight treatments and replicated thrice. The results showed that all the plant growth and flowering parameters were significantly influenced by different growing media, except stem girth. The treatments combination of Garden soil + FYM + Cocopeat (1:1:1), Garden soil + FYM + Rice husk (1:1:1) and Garden soil + FYM + Neem cake (1:1:0.2) was considered the best for the growth and flowering of gaillardia. This suggests that the combination of aforementioned agricultural wastes can provide an environmentally friendly approach for agricultural waste management.

Keywords: Growing media, cocopeat, rice husk, gaillardia, agricultural wastes

Introduction
Gaillardia pulchella Foug. is an annual or short-lived perennial herb native to Florida and Western America. Flowers are single, semi-double, double and even tubular and it can be used in landscaping, interior decorations and coastal dune areas to prevent erosion. Due to its resemblance to chrysanthemums and potential for year-round cultivation, its cultivation has now spread throughout the world.

Crop waste including crop residues is produced in large amounts in India affecting 70% of rural households. Along with crop production farmers generate around 350 MT of waste annually (Pappu *et al*., 2007) [19] and unwise disposal techniques of these wastes threaten the environment and reduce the economic value of waste. Agri-waste as a growth medium is a sustainable choice since agricultural wastes are rich in minerals and nutrients which enhance the physical state of the soil.

The value of potted floriculture plants is known to be greatly influenced by the growth medium and crop residues. The growth of ornamental plants using agricultural waste such as rice hulls, coir, sawdust, crop residues and compost has shown potential substitute for simple soil. FYM is rich in nutrients like N, P and K can be decomposed to provide a large amount of nutrients to crops. Rice hulls are crucial for recycling and ensuring soil productivity and sustainability. Rice straw is rich in nitrogen, potassium and silicon and it is also a valuable fertilizer material that should not be wasted. Use of locally available coir dust as an eco-friendly peat substitute for ornamental plants grown in containers. A significant portion of the non-edible oil cakes and about 30% of the edible oil cakes (World Bank 1998) are disposed annually. It is well known that decomposing various agricultural wastes can improve the physical, chemical and microbiological properties of the soil.

For a better production of Gaillardia flowers, it is necessary to estimate all the growth factors like nutrition, growth media, etc. Thus, application of plant nutrients through organic sources like farm yard manure (FYM) and agricultural wastes like lathyrus husk, rice hulls, cocopeat, crop residues, etc. is a good choice for the growers to maintain sustainable production of Gaillardia. This study was performed to investigate the effect of different agricultural wastes as growing substrates on growth and flowering responses of *Gaillardia pulchella* Foug.

Materials and Methods

The present research work on "effect of different agricultural wastes as growing substrates on growth and flowering responses of *Gaillardia pulchella* Foug.," (cv. Arizona Apricot) was conducted at Horticultural Research cum Instructional Farm, College of Agriculture, IGKV, Raipur (located at 21º 16' N latitude, 81º 31' E longitude and altitude 298.56 m) during the year 2022-23. The experiment was laid out in a completely randomized block design with combinations of eight different treatments (Table 1) and three replications.

The seedlings were raised in polyhouse. Different agricultural waste products considered under the study *viz*., FYM, paddy straw, rice husk, cocopeat, flax stubble, Lathyrus husk, neem cake and mustard cake including garden soil were mixed in varying combinations in equal ratios (v/v) to bring out eight different treatments (Table 1) and kept for decomposition in the field (except T_8) with the addition of bio-decomposers like vermicompost-based *Trichoderma* and *Trichoderma* capsules at a 1:10 ratio and one capsule per treatment, respectively. A regular raking and sprinkling of water have been done. After one month the mediums were filled into the poly bags up to the brim.

Transplanting was done at a rate of one seedling per polybag during the cool evening hours. N, P and K at 150, 80 and 60 kg per hectare respectively, were applied as per the recommendation (Alhajhoj, 2015) [1] and other cultural practices like weeding, irrigation and` plant protection measures remain the same among all treatments. Recording observations was done for growth and flowering parameters *viz*. plant height (cm), plant spread (cm), number of leaves per plant, number of branches per plant, stem girth (mm), root length density (RLD) (cm^{-2}), days taken for first bud appearance, flower head size (cm), number of ray florets, number of flowers per plant and flower yield per plant (g). Physico-chemical characteristics of growing media were determined at 90 days after transplanting and observed for the parameters *viz*. pH, Electrical conductivity (EC) in dSm^{-1}, Organic carbon (%) using the method of Walkey and Black's (1967), available nitrogen, phosphorous and potassium were estimated using method of spectrophotometer and flame-photometer (Jackson, K), respectively.

Table 1: Different treatment combinations of agricultural wastes used as growing substrate

Treatments	Combinations
T_1	Garden soil + FYM + Rice husk (1:1:1)
T_2	Garden soil + FYM + Paddy straw (1:1:1)
T_3	Garden soil + FYM + Cocopeat (1:1:1)
T_4	Garden soil + FYM + Flax stubble (1:1:0.5)
T_5	Garden soil + FYM + Lathyrus husk (1:1:1)
T_6	Garden soil + FYM + Neem cake (1:1:0.2)
T_7	Garden soil + FYM + Mustard cake (1:1:0.4)
T_8	Garden soil (Control)

Result and Discussion

Vegetative parameters

Plant height (cm): The height of the plant was significantly influenced by different combinations of growing media. The results are presented in Table 2. The maximum plant height (26.92 cm) was noticed in T_3 followed by T_6 (24 cm). The longer plants and faster growth rates in 100% and 70% cocopeat-based media can be attributed to the higher water-holding capacity and good aeration conditions of the growing media. The study is consistent with the findings of Padhiyar *et al*. (2017) [18] in chrysanthemum, Madurangani *et al*. (2019) [15] in petunia and Deogade *et al.* (2020) [5] in calendula.

Number of leaves: The number of leaves per plant at 30, 60, 90 and 120 DAT varied significantly (Table 2) among different growing media combinations. T_3 produced the most leaves (262) followed by T_1 (228.9), which performed the best. The highest number of leaves per plant in T_3 (Table 2) can be associated with the properties of media component which includes high water holding capacity, adequate drainage and ample availability of nutrients, which aid in the development of an excellent root system, allow proper nutrient absorption and encourage leaf growth. Similar results were reported by Madurangani *et al*. (2019) [19] in petunia, Thakur and Grewal (2019) [24] in potted chrysanthemum, Chauhan *et al*. (2014) [4] in Gerbera and Deogade *et al*. (2020) [5] in potted calendula.

Number of branches: The number of primary, secondary and tertiary branches varied significantly by different combinations of growing media used, the results are mentioned in Table 2. There were no primary branches produced at 30 days after transplanting (DAT), at 60 DAT, 90 DAT and 120 DAT number of primary branches was higher in T_3. At 30 and 60 DAT, no secondary branches were noticed. More secondary branches at 90 and 120 DAT were observed in T_3. Tertiary branches were seen only at 120 DAT and it was more in T_3. Increased number of branches might due to the organic matter and aeration of media that aided root growth resulting in increased water and nutrient uptake. Similar results were observed by Singh *et al*. (2022) [13] and Khan *et al*. (2021) [11] in chrysanthemum.

Plant spread (cm): Different combinations of growing media used had significant influence on plant spread in both north-south (N-S) and east-west (E-W) directions (Table 4). Maximum spread was observed in T_3 at 30 DAT in both N-S and E-W directions which was followed by T_6. At 60 DAT highest spread was observed in T_3 in both N-S and E-W directions followed by T_6 in N-S and T_1 in E-W direction. Highest plant spread was observed in T_3 at 90 DAT followed by T_1 in both directions. At 120 DAT maximum plant spread was observed in T_3 followed by T_1 in both directions. Cocopeat medium and FYM take care of the moisture availability and nutrition supply of the plant (Nair and Bharathi, 2015) [17]. High C content is associated with enhanced levels of photosynthesis and cell development in plants showing high vegetative growth and better plant spread in media compositions that all include cocopeat as one of their constituents which may have resulted in maximum plant spread. Similar result was observed by Gupta and Dilta (2015) [7] in primula and Wazir *et al*. (2009) [27] in alstroemeria.

Stem girth (mm): Different combinations of growing media had no significant effect on stem girth, the results are given in Table 3. Results have received support from the findings of Keyagha *et al.* (2016) [10], who found that stem girth in *Irvingia wombulu* was not affected by the media. In the study of the comparative effect of different growing media on vegetative and reproductive growth of floral shower (*Antirrhinum majus* L.) by Mehmood *et al*. (2014) [28], the thickest stem girth had greater strength in order to withstand breaking and bending under adverse environmental conditions. According to the statistical analysis, there were no significant differences in stem girth among the different growing media.

Root length density (RLD) (cm^{-2}): Table 3 showed that different growing media combinations had a significant influence on root length density. T_6 and T_3 had the highest root length density of 1.30 cm^{-2} and 2.50 cm^{-2} at 60 and 120 DAT, respectively followed by T_1 with 1.30 cm^{-2} and 2.32 cm^{-2} at 60 and 120 DAT, respectively. Cocopeat helps in maintaining the appropriate texture of the growing media and prevents compaction thereby resulting in better root growth. The physical properties like aeration and water holding capacity are probably the most important factors while, among the chemical characteristics, nutritional status and salinity level have a crucial role on plant development (Dewayne *et al*., 2003). Nutrient distribution in the soil is not uniform and nutrients are often found in the upper layers of the soil. As a result, plants can improve the acquisition of nutrients by stimulating developmental programmes that change the structure of the root system (López-Bucio *et al*., 2003) [14] and these might be the reasons for maximum RLD. This was in line with the studies of Bhardwaj (2014) [3] in papaya seedling growth, Treder (2008) [26] in oriental lily, *Osteospermum* cuttings, salvia, viola (Pickering, 1997) and Impatiens.

Days taken for first bud appearance: The data in Table 3 showed that different combinations of growing media had significant influence on the number of days required for first bud appearance. T_3 took lesser days to first bud appearance (60.2 days) followed by T_1 (60.7 days). These findings are consistent with studies reported by Monika *et al*. (2021) [16] in chrysanthemum, Jawaharlal *et al*. 2001 [8] in anthurium and Gupta *et al.* (2004) [6] in gerbera. This could be attributed to organic matter-enriched media which resulted in early first flower bud appearance (Chauhan *et al*., 2014) [4] as well as an adequate number of leaves per plant which resulted in healthy buds and flowers at an early stage (Barreto, 2000) [2]. Early flower bud initiation may be induced by the easy availability and absorption of available nutrients as well as the impact of solar radiation and temperature.

Flower head size (cm): The flower head size was significantly influenced by different growing media combinations; the results are given in Table 3. T_3 had the highest flower head size (6.47 cm) which was at par with T_6 (6.23 cm) and T_1 (6.13 cm). Adequate nutrient supply and ambient temperature conditions may be the reason for good flower head size. The similar results were observed in petunia by Khandaker *et al*. (2019) [12], Rani *et al.* (2005) [20], Lilium cv. Elite, Kumar *et al.* (2022) [13] in calendula and Singh *et al.* (2022) [13] in pot mum chrysanthemum.

Number of ray florets per flower: There was a significant effect of different growing media on number of ray florets, the results were shown in Table 3. T_1 produced a large number of ray florets (42.93) followed by T_3 (22.23). Organic matter is added through the decomposition of cocopeat and rice husk which improves crop nutrient uptake. It could be the reason for the highest ray floret production. The result was in line with the study of Chauhan *et al*. (2014) [4], Barreto (2000) [2], and Kale *et al*. (2009) [9] in gerbera.

Number of flowers per plant: Different combinations of growing media had a significant influence on the number of flowers per plant, results are presented in Table 3. T_3 produced the most flowers (38.53) followed by T_1 (35.33). Vigorous vegetative growth that resulted in increased carbohydrate reserve material as well as proper absorption of all available nutrients, resulting in a greater number of flowers per plant in gerbera (Chauhan *et al*., 2014) [4]. Similar results observed in petunia by Khandaker *et al*. (2019) [12], in pot mum chrysanthemum by Nair and Bharathi (2015) [17], in chrysanthemum by Khan *et* al. (2021) [11] and Thakur (2022) [19], Wazir *et al*. (2009) [27] reported similar findings in Alstroemeria and in gerbera and geranium by Sekar and Sujata (2001) [21] and Singh (2010) [23], respectively.

Flower yield per plant (g): The flower yield per plant was significantly affected by different combinations of growing media, the results are shown in Table 3. The highest flower yield per plant was observed in T_3 with 101.15g which was at par with T_1 of 95.54g. Cocopeat provides porosity for growing roots as well as good aeration for healthy plant growth and having a sufficient number of leaves per plant results in healthy buds and flowers at an early stage and also increased number of branches which in turn increases the flower yield. The result got support from Singh *et al.* (2022) [13] in potted chrysanthemum, Barreto, (2000) [2] in gerbera.

Fig 1: Root systems of Gaillardia plants in 8 different treatments at 120 days after transplanting

Table 2: Effect of different combinations of growing media on plant height, number of leaves at 30, 60, 90 and 120 DAT and leaf length at peak growth stage

Tr. No.	Plant height (cm)				Number of leaves				Number of primary branches			Number of secondary branches	
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	60 DAT	90 DAT	120 DAT	90 DAT	120 DAT
T_1	5.96	13.19	20.63	23.72	10.14	79.82	194.70	228.90	1.25	7.93	8.80	9.67	12.13
T_2	6.28	13.03	17.30	23.05	9.26	48.41	180.20	213.70	1.00	5.60	7.60	7.20	10.73
T_3	7.76	15.23	20.86	26.92	12.75	79.92	212.50	262.00	1.46	11.0	13.20	14.60	17.13
T_4	5.93	12.72	15.14	19.48	8.99	52.83	165.30	196.10	1.25	4.67	7.13	5.67	9.13
T_5	6.03	12.02	19.08	21.71	9.71	49.83	155.40	183.20	0.71	4.13	6.60	5.40	9.07
T_6	6.74	13.36	20.58	24.00	10.99	59.37	175.30	194.70	1.01	7.93	9.73	9.73	12.07
T_7	5.34	10.39	19.57	21.64	9.41	51.37	101.80	134.30	0.71	4.40	6.80	5.93	8.80
T_8	6.63	11.01	16.76	20.61	9.83	46.00	134.90	168.10	0.71	5.07	8.67	5.87	10.27
S.Em±	0.24	0.50	0.33	0.24	0.36	2.23	3.18	7.68	0.20	0.27	0.30	0.31	0.47
C.D (P@5%)	0.72	1.52	0.99	0.72	1.08	6.68	9.55	23.04	0.61	0.81	0.89	0.93	1.43

Where, DAT- Days after transplanting

Table 3: Effect of different combinations of growing media on stem girth at 120 DAT, root length density at 60 and 120 DAT, number of days taken to first bud initiation, Flower head size, number of ray florets per flower, number of flowers per plant and flower yield per plant at peak flowering stage.

Tr. No.	Stem girth (mm)	Root length density (cm^{-2})		Days taken to first bud initiation	Flower head size (cm)	Number of ray florets per flower	Number of flowers per plant	Flower yield per plant (g)
	120 DAT	60 DAT	120 DAT	Peak flowering stage				
T_1	3.75	1.30	2.32	60.73	6.13	24.93	35.33	95.54
T_2	4.20	0.89	1.88	66.27	5.58	22.00	24.00	60.16
T_3	4.43	0.90	2.50	60.20	6.47	22.23	38.53	101.15
T_4	4.40	0.97	1.49	66.52	5.71	20.6	20.13	57.19
T_5	4.34	0.90	1.37	72.40	4.88	21.33	17.27	30.79
T_6	4.43	1.50	1.72	65.33	6.23	22.00	27.20	75.84
T_7	3.88	0.68	1.02	69.98	4.53	20.53	18.27	32.75
T_8	3.62	0.88	1.54	65.27	5.38	20.54	20.93	38.47
S.Em±	0.39	0.03	0.07	1.96	0.147	0.51	0.87	2.53
C.D (P@5%)	ns	0.09	0.20	5.87	0.44	1.54	2.62	7.57

Where, DAT- Days after transplanting

Table 4: Effect of different combinations of growing media on number of primary and secondary branches and plant spread (North-South and East-West direction) at 30, 60, 90 and 120 DAT

Tr. No.	Plant spread (North-South) (cm)				Plant spread (East-West) (cm)			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_1	10.15	19.64	26.28	29.55	9.96	23.18	25.72	27.97
T_2	9.47	18.64	23.62	28.78	9.20	19.03	24.54	29.12
T_3	11.56	24.47	29.26	31.84	11.88	24.84	28.44	32.73
T_4	8.53	15.46	20.54	24.13	7.80	17.95	20.93	24.50
T_5	7.82	17.41	19.75	22.97	7.93	17.83	20.87	22.57
T_6	10.22	21.73	24.48	27.57	10.53	19.51	24.04	26.67
T_7	8.16	18.05	19.65	23.97	6.81	16.17	18.76	21.23
T_8	9.03	18.92	22.38	25.17	9.35	18.75	21.26	22.90
S.Em±	0.37	0.69	0.57	0.73	0.38	0.49	0.56	0.68
C.D (P@5%)	1.12	2.06	1.70	2.20	1.14	1.48	1.68	2.02

Where, DAT- Days after transplanting

Table 5: Physico-chemical characteristics of different combinations of media at 60 DAT

Treatment No.	pH	EC	OC	Nitrogen (available)	Phosphorous (available)	Potassium (available)
		dSm^{-1}	(%)	(kg/ha)		
T_1	7.3	0.9	0.74	213	21.41	1658
T_2	7.8	0.86	0.99	226	34.14	2482
T_3	7.4	0.92	1.61	226	38.14	1827
T_4	7.6	0.87	0.56	213	34.63	2087
T_5	7.5	0.90	1.67	201	26.16	1981
T_6	7.7	0.96	1.48	226	39.69	1247
T_7	6.7	0.9	0.56	201	29.12	1312
T_8	7.5	0.66	0.43	151	39.16	351
Soil	7.7	0.45	0.37	138	21.24	500

Where, EC- Electrical conductivity; OC- Organic carbo

Soil: Physico-chemical characteristics of soil analysed before transplanting without decomposition or addition of any fertilizers

Conclusion

The result indicating the effect of different combinations of agricultural wastes as growing substrate on growth and flowering responses of gaillardia, treatment T_3 performed best with regards to maximum plant height, highest number of leaves, maximum number of branches, highest plant spread, highest stem girth, highest root length density at 120 DAT, early first bud appearance, highest flower head size and disc diameter, highest number of numbers and maximum yield of flowers plant. While, highest number of ray florets were recorded in T_1. The highest root length density at 60 DAT was observed in T_6. Therefore, it can be concluded that growing media containing Garden soil + FYM + Cocopeat, Garden soil + FYM+ Rice husk and Garden soil + FYM + Neem cake were found best for vegetative and flowering parameters of gaillardia plants.

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