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Rejoinder of diverse organic growing media on morphological attributes of nine *Heliconia* species and varieties under West Bengal condition

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ABSTRACT

Predominant constraints for successful thrive of Heliconia the trendiest cut flower of tropics are the shortage of apposite genotypes and growth medium under Bengal circumstance. In this backdrop, a field experiment was conducted being employed Heliconia psittacorum × spathocircinata cv. 'Golden torch', Heliconia psittacorum var. 'Choconiana', Heliconia psittacorum var. 'Lady di', Heliconia rostrata, Heliconia humilis, Heliconia stricta var. 'Dwarf Jamaican Red', Heliconia wagneriana, Heliconia stricta and Heliconia metallica in Agricultural Experimental Farm of University of Calcutta at Baruipur, West Bengal during 2013-2014 and 2014-2015 using six varied growth media viz. top soil (control), river sand, top soil + river sand (1:1), top soil + dry cow-dung-manure (1:1), top soil + vermicompost(1:1) and river sand+vermicompost(1:1). Finest outcomes for all parameters considered obtained by top soil+vermicompost(1:1) and top soil+river sand+vermicompost(1:1) irrespective of species after four weeks of planting. Plant height increased manifold times in all species and varieties but H. stricta attained the highest (395.02cm) while significant plant spreading of 674.22, 354.79 and 903.73cm^2 perceived in 'Golden torch', 'Choconiana' and H. rostrata respectively. Latter two Heliconia plants yielded also maximum number of shoots clump^{-1} (13.01 and 14.12) whereas leaf blade length of 102.72cm. found by H. stricta. Noteworthy stem length noticed in H. wagneriana. On the other hand, sufficiently bigger inflorescences, the most striking part of these plant produced by both H. rostrata and H. stricta (77.11 and 60.95cm). On the contrary, utmost number of inflorescences/plant/year produced by hybrid cultivar 'Golden torch' (102.23). River sand solely failed to prove its competency while the interaction of top soil+cow-dung-manure (1:1) bestowed lowest vegetative traits.

***Keywords*:** *Heliconia*, growth, inflorescence, media and vermi-compost

Production and consumption of tropical flowers are increasing in many countries around the world. Tropical flowers are perceived by many flower consumers as exotic and unusual, with a potential market in temperate countries. In this backdrop *Heliconia* is gaining popularity in world as well as Indian market as an emerging flower crop. Approximately 200 to 250 species are distributed primarily in Neotropical areas from the North of Mexico to the South of Brazil (Santos, 1978; Dahlgren *et al*., 1985; Kress, 1990). They're gaining importance owing to their desirable horticultural properties and postharvest characteristics, much, though, remains to be known about this plant. It contains a group of excellent cut flowers due to their striking shape, attractive color, long vase life and prolific flower producing capacity. Vast morphological diversity at intra-specific, intra-population and varietal levels are observed in this genus.

Predominant constraints for successful thrive of *Heliconia* are the shortage of apposite genotypes and growth medium under West Bengal circumstance. So use of suitable growing media or substrates is essential for production of quality inflorescences of *Heliconia.* Several authors (Ekwu and Mbah, 2007; Baiyeri and Mbah, 2006) had advocated for the replacement of natural top soil as growth medium of floricultural crops with other available options due to some of its shortcomings such as non-sustainability and as a non-renewable resources. Continuous digging of agricultural soils meant for cropping, arable land could make the land susceptible to erosion and other forms of soil degradation (Anon., 2011). Growing media are materials, other than soils *in situ*, in which plants are grown. There are two types of growth media: organic and inorganic. The organic media like peat, compost, tree bark, coconut (*Cocos nucifera* L.Coir), poultry feathers, wood chip, wood shaving, saw dust, while inorganic media are classified into two namely 'Natural' and 'Synthetic' media. Materials include under inorganic natural medium are sand, gravel, rockwool, glass wool, perlite vermiculite, pumice, expanded clay, while the synthetic natural media used materials are foam mats (polyurethane),''Oasis" (plastic foam) hydrogel (Olympios, 1999) *etc*. A perfect growth media serves various function especially enact as a nutrition reservoir in favor of plant's growth and development but as they're quite specific regarding their action that's why organic and inorganic growth media duo are usually applied separately but exception may happen. Since organic substrates are most approachable, eco-friendly and biodegradable, thus, the use of several ecological components could serve as next available alternative.

Hence, the objective of this study was to compare the performance of selected growth media on different

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agro-morphological traits of nine *Heliconia* genotypes under West Bengal condition for its huge entail in both domestic and foreign market and propitious export potential.

MATERIALS AND METHODS

The experiment was carried out in the Agricultural Experimental Farm, University of Calcutta, situated at Baruipur, South 24 Parganas, West Bengal, ($88^0$28' East longitude, $22^0$22' North latitude and 9.75m above sea level). Laboratory experiments were conducted in the Department of Horticulture, Institute of Agricultural Science, University of Calcutta, Kolkata ($22^0$34' North latitude and $88^0$22' East Longitude). The mean maximum and minimum temperature ranged in between 24.8^{0}C-39^{0}C and 10^{0}C-30^{0}C respectively and relative humidity varied in between 54.2-89.5%. The average rainfall was between 1200 to 1800mm having maximum precipitation during June to October.

The rhizomes set planted were obtained from Agri Horticultural Society of India (AHSI) and Kamal Nursery at Andul, Howrah. Each rhizomes set had three nodes and some developed roots at an average weight of 50-70 g and average length of 11-15 cm. The black polythene bags (7" x 9") used initially for the experiment. The topsoil used collected with soil auger at depth of 0-15 cm from Baruipur experimental farm whereas vermi-compost obtained within the farm. The river sand was purchased from 'Global Adsorbents private Limited', Kolkata while cow-dung manure collected from nearby animal husbandry farm of Baruipur.

The experiment was comprised of nine *Heliconia* sp. genotypes namely *H. psittacorum* L.f. *X H. spathocircinata Aristeg*. cv. 'Golden torch', *H. psittacorum* L.f. var. 'Choconiana', *H. psittacorum* L.f. var. 'Lady di', *H. rostrata* Ruiz and Pavón, *H. humilis* (Aubl.) Jacq., *H. stricta* Huber var. 'Dwarf Jamaican Red', *H. wagneriana* Peterson, *H. stricta* Huber and *H. metallica* Planchon and Linden ex Hooker and six organic growing media which were top soil (control), river sand, top soil + river sand@1:1, top soil + dry cow-dung-manure@1:1, top soil + vermin-compost@1:1 and top soil + river sand + vermi-compost@1:1:1s.

The experimental land (25.5 x 19m.) was ploughed and cross-ploughed 2-3 times by power tiller followed by laddering to obtain good tilth followed by removal of stubbles and weeds. Five discrete plots were made using aforementioned organic growth media while clay pots of 20 inches utilized for growing employed genotypes solely on river sand substrate. Total 90 plots, 10 plots for individual genotype were prepared in the field and 10 large clay pots containing sand were used. The entire experimental land was leveled and divided into 30 plots in three rows, each measuring 5 x 2sq.m., with 1m. wide drainage-cum-irrigation channel between each row. *Heliconia*s are commonly propagated by division of rhizomes. Dividing of rhizomes involve making a cut across a section of rhizome (ideally bearing at least one visible 'bud' or new shoots, as well as the base of the leaf stem) followed by planting them in black polyethylene bag (size 7" x 9'') during first week of March, 2013. The rhizomes of more or less uniform in size and weight were planted with the top (leaf stem/ new shoots/buds pointing upwards) not more than 3-4 cm under the soil as this will encourage fungi and cause root rot. The planted rhizomes sprouted within two months. After attaining the height of 30cm. transplanting was carried out in the main field at a distance of 1 x 1m by end-June. Each plot had 10 plants. After planting, thorough watering was given. Soil should be evenly moist, but not wet, especially when shoots tend to grow and leaves start unfolding. Plant protection measures were carried out at regular intervals by application of botanical (neem based) and chemical pesticides. The plants were grown under semi shaded condition.

All vegetative and floral characters taken into consideration were inflorescence length, number of inflorescence plant $^{-1}$ year^{-1}, plant height (cm.), plant spreading (cm^2), leaf blade length (cm.), stem length (cm), number of shoots per clump, number of leaves per stem, number of flowering stems per clump, root length and number of roots.

The experiments were conducted in Randomized Block Design (RBD) with factorial concept (Panse and Sukhatme, 1985) having two replications for each genotype. The data were subjected to ANOVA using SPSS 10.0 statistical package. The treatment means were compared by Duncan's New Multiple Range Test (DNMRT) at 5 percent probability level.

RESULTS AND DISCUSSION

Physiochemical properties of the growing media pose their effect on the plant growth (Wilkerson, 2002); therefore the composition of the growth media is vital factor to be taken under consideration (Ingram *et al*., 2003). Some physiochemical properties of the selected growth media are presented in the table 1. Results showed that the sand particles ranged from 99.10-13.97 per cent with the highest value in river sand followed by Top soil + river sand (1:1) media and lowest in top soil + vermi-compost (1:1). Silt particle ranged from 0.10 to 27.30 per cent with top soil producing the highest value and the lowest in sole river sand medium. Clay particle followed the same trend as silt particle. The pH value ranged from 5.21 to 7.09 with having the highest value in river sand and top soil + dry cow-dung-manure (1:1) the lowest. Highest 44.62% total organic carbon (TOC) was found in top soil + vermi-compost (1:1) followed

by 43.23% in top soil + river sand + vermi-compost (1:1) while river sand contained lowest (0.63%) TOC. It is lucid from the table 1 that the mixture of top soil and vermi-compost (media) hold the utmost amount of total N, available P and K, exchangeable Ca and Mg also, that's why vermin-compost is gaining interest as a greener replacement or integration with chemical fertilizers to maintain and further improve soil quality (Lim *et al*., 2014). On the other hand, minimum 0.08% total N in top soil, 1.23 and 101.05 ppm available P and K in river sand and top soil + river sand and exchangeable Ca and Mg of 0.13 and 0.18 m.e 100^{-1} g soil in river sand were evident here. Electrical conductivity (Ec) ranged from 0.14 to 2.15 m. mohs cmm^{-1} with the mixture of top soil and vermi-compost having the highest value and top soil followed by top soil + river sand the lowest.

Table 1: Some physio-chemical properties of the selected growth media

Growth Media	Sand (%)	Silt (%)	Clay (%)	pH (H_2O)	TOC (%)	Total N (%)	Avail P (ppm)	Exch Ca (me 100^{-1} g soil)	Exch Mg (me 100^{-1} g soil)	Avail K (ppm)	EC (m.mhos cmm^{-1})
Top soil	16.20	27.30	50.50	6.60	0.90	0.08	24.00	16.80	9.10	220.00	0.14
River sand	99.10	0.10	0.80	7.09	0.63	0.09	1.23	0.13	0.18	199.00	0.23
Top soil + river sand (1:1)	95.25	0.95	45.80	6.25	2.02	0.10	14.95	15.50	7.10	101.05	0.15
Top soil + dry cow-dung-manure (1:1)	17.25	20.82	49.92	5.21	31.83	0.52	192.87	14.78	5.47	225.00	1.04
Top soil + vermi-compost (1:1)	13.97	21.80	46.40	6.10	44.62	3.32	484.50	21.40	12.75	454.00	2.15
Top soil+River sand + vermi-compost (1:1:1)	15.55	20.11	42.40	6.94	43.23	3.30	396.59	20.13	12.39	422.00	2.02

Note: TOC - Total organic carbon, Avail - Available, Exch - Exchangeable and EC - Electrical conductivity

Plant height and plant spreading's

The impact of chosen organic growth media on plant height and plant spreading's of nine *Heliconia* species and varieties presented in the table 2. Here, for both parameters finest outcomes manifested by top soil + vermi-compost (1:1) while top soil + river sand + vermi-compost (1:1:1) could be contemplated as the second best organic growth media. Similar results were reported by Conover and Poole, 1981. Normally, plant height of employed genotypes ranged from 45.11-307.85cm while 138.99-1047.29 cm^2 for plant spreading's found in top soil. By (planting in) top soil + vermi-compost (1:1) media plant height was acceptably augmented by 37.18 cm, 42.67 cm, 80.17 cm, 40.23 cm, 24.69 cm, 44.51 cm, 42.37 cm. 87.17 cm and 44.50 cm for cultivar 'Golden Torch', variety 'Choconiana' and 'Lady Di', *H. humilis*, *H. stricta* var. 'Dwarf Jamaican Red', *H. metallica*, *H. rostrata*, *H. stricta* and *H. wagneriana* respectively. Mixing of river sand along with top soil and vermi-compost could too yield significant outputs on plant height of used genotypes (Table 2). Vermi-compost provides micro and macro nutrients to the soil and enhances soil aeration (Mundiyara and Jat, 2017; Saranraj and Stella, 2012). Here, sole river sand media failed to increase plant's height but while it was mixed with top soil then astonishingly the impact was moderately fine. Plant height obtained in case of 'Choconiana' (128.32cm), *H. humilis* (149.96cm), *H. stricta* var. 'Dwarf Jamaican Red' (56.44cm), *H. rostrata* (188.06cm), *H. stricta* (344.12cm) and *H. wagneriana* (274.93cm) by top soil+river sand media were more or less at par with the outcome of top soil + river sand + vermi-compost (1:1:1) media. Lastly, any noteworthy response of top soil + cow-dung-manure (1:1) media was not evinced here.

For plant spreading's almost the akin trend was received but for this trait top soil + vermi-compost as well as top soil + river sand + vermi-compost media revealed notable outcome (Table 2). Combination of river sand along with top soil for variety 'Choconiana' and 'Lady Di' (304.19 and 209.4 cm^2), *H. humilis* (310.59 cm^2), *H. metallica* (943.97 cm^2), *H. rostrata* (884.53 cm^2) and *H. stricta* (868.38 cm^2) were enough passable while river sand alone was totally unsuccessful. Abad *et al.* (2002) reported that coarser particles of sand and mineral impurities in natural colored sand aid in plant growth. In *H. wagneriana* all utilized media enhanced its spreadings significantly as compare to control media except river sand media where a decrease in plant spreadings of 134.50cm^2 had evinced (Table 2).

Table 2: The effect of selected growth media on flowering and vegetative traits of nine *Heliconia* species and varieties

Media used	Plant height (cm)								
	***H. psittacorum* × *H. spathocircinata* cv. GoldenTorch**	***H. psittacoum* var. 'Choconiana'**	***H. psittacorum* var. 'Lady Di'**	***H. humilis***	***H. stricta* var. Dwarf Jamaican Red**	***H. metallica***	***H. rostrata***	***H. stricta***	***H. wagneriana***
Top soil	91.14c	112.78d	68.88e	147.22bc	45.11c	92.35d	177.70c	307.85bc	272.19bc
Top soil+ vermi-compost	128.32a	155.45a	149.05a	187.45a	69.8a	136.86a	220.07a	395.02a	316.69a
Top soil+river sand+vermi-compost	97.84b	124.97c	117.35b	153.92b	58.52b	120.09b	186.54b	352.35a	283.16b
Top soil+river sand	94.49bc	128.32b	89.00d	149.96bc	56.44b	106.68c	188.06b	344.12b	274.93bc
Top soil+cow-dung-manure	91.74c	124.05c	71.93c	148.13bc	48.77c	101.19c	181.36bc	332.84b	277.98bc
River sand	90.12c	105.02de	71.10c	132.01c	41.91cd	85.17e	161.09d	219.19c	205.09c
Plant spreadings (cm^2)									
Top soil	601.68c	284.68bc	166.42c	284.38c	138.99cd	917.75bc	868.38c	859.23b	1047.29b
Top soil+vermi-compost	674.22a	354.79a	248.41a	359.36a	194.77a	981.15a	903.73a	885.44a	1069.54a
Top soil+river sand+vermi-compost	640.69b	321.26ab	213.66a	325.83a	164.29b	947.62ab	899.46b	882.40a	1066.50a
Top soil+river sand	614.17c	304.19b	209.4b	310.59b	143.87c	943.97b	884.53b	868.38b	1061.01a
Top soil+cow-dung-manure	608.99c	297.18bc	185.62c	300.23b	143.26c	939.39b	886.97b	868.68b	1060.70a
River sand	555.01d	202.92cd	142.11cd	215.89d	102.92d	825.12c	792.01d	725.87c	912.79c
Leaf blade length (cm.)									
Top soil	32.60ab	48.43bc	27.80c	59.80b	30.60b	96.45bc	93.93bc	101.36b	106.56c
Top soil+vermi-compost	33.91a	50.11a	29.85a	60.91a	31.80a	98.07a	95.04a	102.72a	108.19a
Top soil+river sand+vermi-compost	33.21a	49.01b	28.81b	60.01a	31.20a	97.55b	94.54b	102.02a	107.89b
Top soil+river sand	32.99ab	49.25b	28.28b	59.99b	31.07a	97.05b	94.19b	101.89b	107.09b
Top soil+cow-dung-manure	32.90ab	48.99bc	28.08b	59.90b	31.10a	96.79bc	94.20b	101.90b	106.90c
River sand	29.08bc	41.23c	20.59d	46.23c	21.06c	84.26d	82.13d	90.56c	91.23d

Note: Similar words are not significant i.e. they are statistically at par.

Table 3: The effect of selected growth media on flowering and vegetative traits of nine *Heliconia* species and varieties

Media used	*H. psittacorum* × *H. spathocircinata* cv. GoldenTorch	*H. psittacoum* var. 'Choconiana'	*H. psittacorum* var. 'Lady Di'	*H. humilis*	*H. stricta* var. Dwarf Jamaican Red	*H. metallica*	*H. rostrata*	*H. stricta*	*H. wagneriana*
	No. of shoots clump^{-1}								
Top soil	6.01d	10.33c	5.23cd	6.66c	10.96c	6.56c	10.05cd	5.46d	6.23c
Top soil+vermi-compost	9.12a	13.01a	9.14a	8.92a	13.09a	8.46a	14.12a	8.78a	10.31a
Top soil+river sand+vermi-compost	8.11b	12.79b	7.58b	8.01a	12.12b	7.79b	14.01a	7.48ab	10.50a
Top soil+ river sand	8.12b	12.07b	6.53bc	7.79b	12.80b	7.23b	12.78b	7.12b	8.43b
Top soil+cow-dung-manure	7.21c	11.12bc	6.19c	7.05bc	5.18e	6.05c	11.74c	6.29c	6.69c
River sand	4.09e	8.48d	3.08d	4.89d	8.10d	4.26d	7.26d	3.69e	4.29d
	No. of leaves per stem								
Top soil	5.21c	5.96d	6.01cd	5.12e	4.18d	4.66d	5.08d	7.48c	3.69d
Top soil+vermi-compost	7.48a	8.56a	9.08a	9.36a	7.14a	8.96a	9.25a	10.15a	6.18a
Top soil+river sand+vermi-compost	6.54b	8.15a	7.98b	8.45b	6.39b	8.09a	8.57b	10.26a	6.34a
Top soil+ river sand	6.32b	7.85b	6.28c	7.16c	5.69c	6.79b	8.24b	9.31b	5.12b
Top soil+cow-dung-manure	6.03bc	6.12c	6.85bc	6.43d	5.61c	5.12c	7.09c	8.01c	4.12c
River sand	4.1d	3.20e	3.09d	4.12f	3.06e	2.95e	3.06e	5.06d	2.99e
	No. of flowering stem clump^{-1}								
Top soil	4.12d	4.66e	5.26d	4.69d	4.12d	6.66d	3.06d	5.33d	4.12d
Top soil+vermi-compost	8.26a	8.16a	9.65a	7.85a	8.26a	9.01a	7.45a	8.15a	8.24a
Top soil+river sand+vermi-compost	8.12a	7.71b	8.29b	7.89a	8.06a	8.62b	6.31b	7.89b	8.05a
Top soil+ river sand	7.41b	6.19c	7.56c	6.41b	6.02b	8.05bc	6.31b	6.23c	6.12b
Top soil+cow-dung-manure	5.12c	5.22d	7.08c	5.95c	5.65c	7.21c	4.12c	6.01cd	5.94c
River sand	1.06e	1.99f	2.21e	2.05e	2.15e	3.01e	2.06e	2.56e	2.85e

Note: Similar words are not significant i.e. they are statistically at par.

Table 4: The effect of selected growth media on flowering and vegetative traits of nine *Heliconia* species and varieties

Media used	*H. psittacorum* × *H. spathocircinata* cv. GoldenTorch	*H. psittacoum* var. 'Choconiana'	*H. psittacorum* var. 'Lady Di'	*H. humilis*	*H. stricta* var. Dwarf Jamaican Red	*H. metallica*	*H. rostrata*	*H. stricta*	*H. wagneriana*
	Stem length (cm)								
Top soil	35.32c	25.41cd	25.33d	53.28c	20.39d	30.53c	150.41c	147.49d	152.42b
Top soil+vermi-compost	37.01a	28.20a	28.09a	55.82a	23.05a	32.56a	152.14a	150.01a	155.12a
Top soil+river sand+vermi-compost	36.21b	28.01a	27.45b	55.19a	22.67b	32.22a	152.09a	149.74b	155.01a
Top soil+river sand	35.92c	27.81b	27.01b	54.67b	22.02b	31.75b	151.86b	149.04b	151.93c
Top soil+cow-dung-manure	34.69d	26.91c	26.87c	54.01b	21.32c	31.69b	151.01b	148.22c	150.25cd
River sand	30.21e	21.02e	21.26e	48.06d	18.23e	25.06d	138.12d	138.28e	139.69e
	Inflorescence length (cm)								
Top soil	30.12c	48.34c	30.44d	27.30d	16.59c	40.56d	75.12c	58.40c	30.46d
Top soil+vermi-compost	33.59a	50.25a	33.61a	30.29a	19.05a	43.62a	77.11a	60.95a	33.08a
Top soil+river sand+vermi-compost	33.07a	50.11a	32.72b	29.29b	18.96b	43.17a	76.91b	60.07a	32.49b
Top soil+river sand	32.71b	49.75b	32.37b	28.50c	18.04b	42.56b	76.29b	59.81b	32.01bc
Top soil+cow-dung-manure	32.05b	49.06b	31.64c	27.11d	16.01cd	41.79c	75.03c	58.53c	31.29c
River sand	28.11d	45.61d	25.26e	23.01e	11.29e	35.61e	61.02d	49.91d	22.31e
	No. of inflorescences per plant per year								
Top soil	98.00c	54.60cd	52.60bc	29.60c	23.00d	15.66c	48.60c	37.33bc	16.66d
Top soil+vermi-compost	102.23a	59.72a	57.19a	33.21a	27.56a	19.92a	52.69a	40.92a	21.25a
Top soil+river sand+vermi-compost	102.00a	58.12b	56.25ab	33.04a	26.00b	18.25b	51.16ab	39.29bab	21.17a
Top soil+river sand	100.28b	56.52c	55.09b	31.12b	25.00c	17.07bc	50.47b	39.01ab	19.23b
Top soil+cow-dung-manure	80.03c	49.03d	50.23c	27.27c	19.64e	13.09c	41.98c	29.22d	14.37d
River sand	70.02d	32.19e	30.21d	14.69d	12.90e	8.33d	22.37d	19.92d	9.09e

Note: Similar words are not significant i.e. they are statistically at par.

Table 5: The effect of selected growth media on flowering and vegetative traits of nine *Heliconia* species and varieties

Media used	*H. psittacorum* × *H. spathocircinata* cv. GoldenTorch	*H. psittacoum* var. 'Choconiana'	*H. psittacorum* var. 'Lady Di'	*H. humilis*	*H. stricta* var. Dwarf Jamaican Red	*H. metallica*	*H. rostrata*	*H. stricta*	*H. wagneriana*
				Root length (cm)					
Top soil	5.11c	4.26c	4.01c	5.65b	3.89c	3.16d	4.52c	5.69c	5.82c
Top soil+vermi-compost	7.02a	6.82a	6.59a	6.95a	5.50b	6.20a	6.67a	7.02a	7.82a
Top soil+river sand+vermi-compost	6.05b	6.29a	6.73a	5.81b	6.02a	5.71b	5.90b	6.97b	6.14b
Top soil+river sand	4.91d	5.02b	5.23b	4.69c	5.50b	4.98c	5.01bc	4.52d	4.72d
Top soil+cow-dung-manure	4.11d	4.05cd	4.29c	4.76c	5.09bc	5.31b	4.81c	5.01c	4.67d
River sand	2.15e	2.07e	2.19d	2.51d	3.06cd	3.10d	2.71d	2.11e	2.04e
				No. of roots					
Top soil	5.00d	6.00c	5.00c	7.00c	5.00c	6.00c	7.00c	7.00b	5.00d
Top soil+vermi-compost	20.00a	18.00a	20.00a	16.00b	17.00a	18.00a	20.00a	15.00a	20.00a
Top soil+river sand+vermi-compost	10.00b	15.00b	10.00b	20.00a	17.00a	16.00b	15.00a	15.00a	14.00b
Top soil+river sand	7.00c	4.00d	5.00c	7.00c	6.00b	6.00c	5.00cd	4.00c	7.00c
Top soil+cow-dung-manure	5.00c	7.00c	6.00c	5.00d	5.00c	6.00c	7.00c	7.00b	8.00c
River sand	3.00d	4.00d	3.00d	2.00e	4.00c	3.00d	3.00e	2.00d	2.00e

Note: Similar words are not significant i.e. they are statistically at par.

Leaf blade length and number of leaves

Furthermore, number of leaves is also found to be positively correlated with the number of flowering shoots per plant in *Heliconia*. Here, the increase or decrease of afore stated traits were documented in the table 2 and 3. Any startling increase in leaf blade length as compare to control (Top soil) was not perceived here but Top soil + Vermi-compost media was quite effective. This media enhanced 1.31, 1.68, 2.05, 1.11, 1.2, 1.62, 1.11, 1.36 and 1.63 cm length of foliage of cultivar 'Golden Torch', variety 'Choconiana' and 'Lady Di', *H. humilis*, *H. stricta* var. 'Dwarf Jamaican Red', *H. metallica*, *H. rostrata*, *H. stricta* and *H. wagneriana* respectively. Vermi-compost restores microbial population which includes nitrogen fixers and phosphate solubilizers (Cernac *et al*., 2006). Unexpectedly, except river sand media the rest three media exhibited noticeable impact on leaf's length. More clearly, the consequences of rest three treatments were at par with the superior media (Top soil + Vermi-compost) (Table 2).

In cultivar 'Golden Torch' 2.27, variety 'Choconiana' 2.6, 'Lady Di' 3.07, *H. humilis* 4.24, *H. stricta* var. 'Dwarf Jamaican Red' 2.98, *H. metallica* 4.3, *H. rostrata* 4.17, *H. stricta* 2.67and *H. wagneriana* 2.49 no. of leaves were increased in compare with control (Table 3). Numbers of leaves or vegetative growth generally depend upon the nutrients taken or absorbed from media in which it's sown (Diaz-Zorita *et al*., 2005). Based on the accumulated data Top soil + river sand + Vermi-compost could be considered as second best for amplifying the leaves number (Table 3). Inflation of no. of leaves/stem by Top soil + river sand media was merely observed in 'Golden Torch' (6.32), 'Choconiana' (7.85), *H. metallica* (6.79), *H. rostrata* (8.24), *H. stricta* (9.31) and *H. wagneriana* (5.12). Top soil + cow-dung-manure and river sand duo yield disappointed outcomes here also (Table 3) may be for compactness of soil which restrict nutrient up take (Waziri *et al*., 2015).

Number of shoots per clump and stem length

No. of shoots per clump generally varied from 5.23-14.12 for the involved *Heliconia* species and varieties here. Table 3 exhibited the maximum augmentation of no. of shoots/clump by top soil + vermi-compost whereas the impact of top soil + river sand + vermi-compost and top soil + river sand media were certainly not negligible. But in river sand media no. of shoots per clump was decreased drastically *i.e.* in 'Golden Torch' 4.09, 'Choconiana' 8.48, 'Lady Di' 3.08, *H. humilis* 4.89, *H. stricta* var. 'Dwarf Jamaican Red' 8.10, *H. metallica* 4.26, *H. rostrata* 7.26, *H. stricta* 3.69 and *H. wagneriana* 4.29 in collate to control (Top soil). The results from the findings are also in support from previous work done by Wuryaningsih *et al*., 1999. The increase of shoots by combination of top soil and cow-dung-manure was inconsequential.

Overall, 2-3 times increase in stem length was evinced for all summoned genotypes in contrast to Control by Top soil + Vermi-compost and Top soil + river sand + Vermi-compost (Table 4). Enhancement of length was at par by both of these organic media while notable decline was found for river sand media solely. Richer nutritional status of soil which enhanced photosynthetic activity resulted in more plant stored material, thereby increasing the length. Similarly lesser stem length in top soil (control) and sole river sand might be due to less soil aeration and poor root penetration which had restricted the plant growth (Pramanik and Chung, 2011; Aira and Dominguez, 2008). It had been found that in case of *H. humilis*, *H. metallica* and *H. rostrata* the raise of stem length were exactly similar by Top soil + river sand and Top soil + cow-dung-manure both while the difference in response by above medias for other genotypes were almost negligible (Table 4).

Number of flowering stems per clump, inflorescence length and productivity per annum

Ornamentally precious part of *Heliconia* sp. is its striking inflorescence, so the production of flowering stem per clump is undoubtedly a vital issue. Here also, top soil + vermi-compost media found unparallel among others (Table 3). 'Golden Torch', 'Choconiana', 'Lady Di', *H. humilis*, *H. stricta* var. 'Dwarf Jamaican Red', *H. metallica*, *H. rostrata*, *H. stricta* and *H. wagneriana* produced 8.26, 8.16, 9.65, 7.85, 8.26, 9.01, 7.45, 8.15 and 8.24 flowering stems respectively as compare to Top soil. Results are also in line with that of Olosunde *et al*., 2015. The other two medias *viz.* top soil + river sand + vermi-compost and Top soil + river sand could be contemplated as second best medias (Table 3). Immense export potential of cut inflorescences also makes its yield/annum a major concern. Utmost yield obtained by top soil + vermi-compost and top soil + river sand + vermi-compost duo irrespective of employed genotypes (Table 4). Vermicasts are homogenous in nature, have reduced level of contamination and contain elevated levels of plant growth regulators or symbiotic microbes and organic acids like humic and fulvic acid (Edwards *et al*., 1988). Inflorescence production plant^{-1} year^{-1} by top soil + river sand media was moderately satisfactory too in comparison with control. But it is lucid from the table- 3 and 4 that top soil + cow-dung-manure and river sand both failed to prove their competency regarding yearly yield and production of flowering stem/clump may be for low nutritional status for plant offered by the medium.

Inflorescence length of all genotypes was increased by 2-3cm by top soil + vermi-compost and top soil +

river sand + vermi-compost media (Table 4). Akin outcome also obtained by Garg *et al*., 2006; Karthikeyan *et al*., 2007 and Reddy *et al*., 2009. Morphological characters of inflorescence were evaluated based on methodology of Castro C.E.F (1997), describing inflorescence length as short (<10cm), medium (10.1-30cm), long (30.1-50cm) and very long (>50cm). Based on the recorded data, inflorescences of Golden Torch, Choconiana , Lady Di , *H. humilis, H. metallica* and *H. wagneriana* could be categorized as 'Long' category while, *H. rostrata, H. stricta* as 'Very Long' and *H. stricta* var. 'Dwarf Jamaican Red' as 'Medium' category.

Root length and number of roots

The effect of selected growth media on root length and no. of roots of *Heliconia* sp. has presented in table 5. Here also the same trend was found *i.e.* only Top soil + vermi-compost and Top soil + river sand + vermi-compost media produced longest root (Table 5) than control but emergence of maximum no of roots were found merely by Top soil + vermi-compost. The first stage of growth of the plant usually takes nutrients stored in the rhizomes, when the nutrients are depleted the plant depends upon the root up- take from the soil or from the media (Remison, 1997) so enriched media provide sufficient reliance to amplify roots. Rest of the media becomes futile to yield any noteworthy output evident from the table 5. Outstanding findings drawn from this study showed that nine varieties of flowering *Heliconia* responded well to the selected growth media. Topsoil + vermi-compost (1:1) and Top soil + river sand + vermi-compost (1:1) were the best candidate media to produce flowers judged from their satisfactory growth performances while river sand were adjudged as the worst candidate media because of their unsatisfactory growth performance. In conclusion, combinations of Topsoil + vermi-compost (1:1) can the best growing medium for employed genotypes under the area of study (West-Bengal). However, the continual use of top soil as a candidate growth medium needs to be discouraged because soil degradation, non-sustainability and non-renewability associated with it. The eco-friendly and biodegradable nature of organic substrates facilitating their use as next available alternative.

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