Influence of Organic Manures and Spacing on Herbage Yield in Tulsi (*ocimum sanctum L.)*

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Abstract
Ocimum sanctum L.is commonly known as Tulsi or Holy Basil, which is a species worshipped by the Hindus. *Ocimum sanctum* belongs to the family Lamiaceae. The economically important part of *Ocimum sanctum* is its herb (leaves and tender parts of the shoots).Very few studies have been carried out in the development of agro techniques for its commercial cultivation. The crop geometry or plant spatial arrangement and appropriate use of manures are considered to be very important for crop quality. Based on the results of the present study it was inferred that application of vermicompost at the rate of 5 t ha^{-1} under wider spacing of 50 x 30 cm was the best management practices getting higher productivity and can be recommended for effective and economic management practices for Tulsi.

Keywords: Herbage yield, Organic manures, Spacing, Tulsi
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Introduction
Medicinal plant sector has traditionally occupied an important position in the socio cultural, spiritual and medicinal arena of rural and tribal lives of India. India with its varied biodiversity has a tremendous potential and advantage in this emerging area as indicated by the National Medicinal Plants Board, New Delhi. Only few plants are cultivated and the remaining plants are collected from wild source. Due to increasing demand in the pharmaceutical industries, the scientific cultivation of medicinal plants is a need of the day.

In India, basil is popularly known as Tulsi and is the most sacred and holy plant of India. Organic basil is considered as the best herb used as herbal supplement. Basil is among the most popular of herbs grown in gardens and spice cabinets all over the world. Basil is an important constituent in many Ayurvedic cough syrups and expectorants, and commonly referred as "Wonder herb". The essential oil from the herbage is used in pharmaceutical preparations, in perfumes and cosmetics and as flavouring agent in many foods (Prabhu *et al.*, 2010).

Materials and Methods
The experiment was laid out in split plot design with three replicates. The experiment consisted of three main plot treatments (organic manures) *viz.*, M_1 - FYM at 20 t ha^{-1}, M_2 -Vermicompost at 5 t ha^{-1}, M_3-Humic acid at 20kgha^{-1}, and five subplot treatments (Spacing) S_1-30x45cm, S_2-45x45cm, S_3-45x60cm, S_4-50x30cm, S_5-60x60 cm. The nursery was raised during July, 2013. Nursery beds of 0.5cm width, 0.1m height and 2.0m length were prepared by incorporating FYM and sand. 60g of seeds were mixed with sand and then sown in lines at 10 cm apart in raised beds. Plots of 3m x 4m size were prepared and a bund was provided in between the two plots. The land was converted into ridges and furrowed as per the spacing. Thirty five days old seedlings were transplanted to the main field at 4 to 6 leaf stage during the month of August. The observation on herbage yield was taken in early morning at 90-95 days after transplanting. For leaf production, the crop was harvested at flower initiation stage. The first crop was harvested in second week of November by weighing each plant in every treatment and expressed in g plant^{-1} and computed with the total number of plants per hectare and expressed in t ha^{-1}.

Results and Discussion
The main plot M_2 (Vermicompost at 5 t ha^{-1}) has recorded the highest herbage yield per hectare of 4.75 t at 90 days after transplanting and was on par with M_1 (FYM at 20 t ha^{-1}) 4.69 t at 90 days after transplanting (Table1). The subplot spacing treatment S_4 (50 x 30 cm) recorded the highest herbage yield per hectare of 6.21t at 90 days after planting. The treatment combination of M_2S_4 (Vermicompost at 5 t ha^{-1} with 50 x 30 cm) recorded the highest herbage yield per hectare of 6.80 t at 90 days after transplanting and was on par with M_1S_4 (FYM 20 t ha^{-1} with 50 x 30 cm) 6.68 t at 90 days after transplanting (Table 1).Higher yield due to the application of vermicompost may be attributed to their favourable effects in improving the physical conditions of the soil, besides supplying

Table 1: Influence of organic manures and spacing on herbage yield of *Ocimum sanctum* L. at harvesting stage

Treatment	Yield/plant (g plant^{-1}) at 90 Days after transplanting				Yield/ha (t ha^{-1}) at 90 Days after transplanting			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	102.53	100.260	100.80	**101.20**	5.32	5.20	5.23	**5.25**
S_2	120.40	110.39	100.60	**110.47**	4.14	3.79	3.46	**3.80**
S_3	121.30	128.53	117.53	**122.46**	3.18	3.37	3.08	**3.21**
S_4	136.30	138.93	105.39	**126.88**	6.68	6.80	5.16	**6.21**
S_5	117.80	131.06	126.20	**125.02**	4.12	4.58	4.41	**4.38**
Mean	**119.67**	**121.84**	**110.11**	**117.20**	**4.69**	**4.75**	**4.27**	**4.57**

	SEd	CD @ 5%	SEd	CD @ 5%
M	1.25	3.48*	0.04	0.11*
S	1.96	4.04*	0.04	0.08*
M at S	3.28	7.11*	0.07	0.17*
S at M	3.39	7.00*	0.07	0.14*

Main plot (Organics)	Sub plot (Spacing)
M_1-FYM at 20 t ha^{-1}	S_1- 30 x 45 cm
M_2-Vermicompost at 5 t ha^{-1}	S_2- 45 x 45 cm
M_3-Humic acid at 20 kg ha^{-1}	S_3-45 x 60 cm
	S_4-50 x 30 cm
	S_5-60 x 60 cm

adequate major and minor nutrients which might have enhanced the absorption, translocation and assimilation of nutrients resulting in higher yields as suggested by Sivakumar and Ponnusami, (2004) in Black night shade. These findings were close to Rajamanickam *et al.* (2011) and Chand *et al.* (2001) in Mint. The abundant space between rows resulted in less competition between the plants for food (nutrients), better interception of solar radiation by the completely covered crop canopy (obtained from plant spread data), increased in vegetative growth and closer spacing between plants gave higher plant population thereby resulted in higher herbage yield. The another possible reason for higher yield in wider spacing may be due to higher plant spread which results in lesser weed growth.

References

Chand S, Anwar M and Patra DD 2001. Influence of combined application of Farm Yard Manure (FYM) and inorganic fertilizer on herb, essential oil yield and nutrient accumulation in Menthol Mint (*Mentha arvensis*). J. Med. Arom. Pl. Sci. 23: 29-33.

Prabhu M, Kumar AR and Rajamani K 2010. Influence of different organic substances on growth and herbage yield of Scared Basil (*Ocimum sanctum* L.). Indian J. Agric. Research. 44 (1): 48-52.

Rajamanickam V, Venkatesan S and Shakila A 2011. Effect of organic manures, consortium of biofertilizers and inorganic fertilizers on yield, nutrient uptake and profitability of mint (*Mentha arvensis* L.). The Asian Journal of Horticulture, 6 (1): 191-194.

Sivakumar V and Ponnusami V 2004. Influence of spacing and organics on plant nutrient uptake of black nightshade (*Solanu nigrum*) International Journal of Agricutural Extension and Rural Development. 1(1):5-7.

Morphological Variations of Twelve Accessions of the Traditional Rice, Heenati, Deposited at the Plant Genetic Resource Center, Sri Lanka

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Abstract
Twelve Heenatirice accessions collected from the plant genetic resources centre (PGRC), Gannoruwa, Sri Lanka were evaluated on the basis of 12 agro-morphological traits in a field experiment during major (*Maha*) season, 2012/13 and 2013/14. The aim of the study was to distinguish the traditional rice accessions identified as Heenati and catalogued under different accessions at PGRC are similar or not in morphological characteristics. Three-week-old seedlings of the accessions were transplanted in rows with 15 cm x 20 cm spacing according to randomized complete block design. Three replicates were arranged for each accession and each replicate consisted of 3 rows of seedlings while 20 plants were included in to each row. Agro-morphological traits, biomass and harvest index of middle row plants were recorded according to the Standard Evaluation System for Rice, IRRI. The data were statically analysed using the SPSS version 20 software. Principal Component analysis (PCA), cluster analysis and morphological dendrograms using Ward Linkage were used to assess the patterns of the morphological variation. The first three principle components (PCs) explained over 80% of the total variation associated within the accessions. Among them the first two principle components cumulatively explained 61.7% of the total variation. All the accessions catalogued under different accession numbers were not significantly different in relation to considered characteristics and all the accessions distinguished in the same name were also not similar in their morphological traits. According to the cluster analysis, Rathu Heenati-5486 rice accession was significantly different from the other Rathu Heentirice accessions at rescaled cluster distance 25. Six Kalu Heenati rice accessions were also grouped into two clusters at cluster distance 13. It can be concluded that rice accessions with the same name may not always belong to the particular cultivar though they have the same name.

Keywords: Heenati, Morphological characteristics, Principal component analysis, Traditional rice accessions
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Introduction
Traditional rice varieties reserve broad range of traits to introduce into elite lines in rice improvement programs which aim to enhance the rice productivity under different agro-climatological conditions (Lasalita-Zapico *et al.*, 2010). The qualities in cooked-rice such as high fibre content and medicinal properties in traditional rice cultivars have gained rice consumers' attention (Wickramasinghe and Noda, 2008).

Among the germplasm collection at plant genetic resources center, Gannoruwa, Sri Lanka, the group of Heenati is low yielding but consist of valuable medical compounds (Seneviniwan, 2010). In the ancient time, Heenati was served to lactating mothers to ensure the good health of both the infant and feeding mother. The group of Heenati has been identified to contain different cultivars such as Heenati, Goda Heenati, Sudu Heenati, Kalu Heenati, Rathu Heenati, Gam Heenati and Thavulu Heenati were considered as the healthiest.

Heenati is reported to be tolerant at biotic stresses. Heeneti-309 scored the highest survival rate at submergence (96.74%) and drought (86.67%) stresses at seedling stage (Ranawake *et al.*, 2014a). Under salinity stress, it has scored only 19.81% survival rate (Ranawake *et al.*, 2014a). In a different study carried out by Ranawake *et al.* (2014b), it has been reported that leaf extracts of Kalu Heenati significantly reduced the seed germination of common weed, *Echinochloa crusgalli* L. which emphasizes the allelopathic effect of Kalu Heenati leaf extract.

Plant genetic resources centre, Gannoruwa, Sri Lanka conserves the seeds of traditional rice accessions. During collection of these accessions they were given the common name and an accession number. Hence there are several rice accessions in the same name in this collection though they were given different accession numbers during the collection. Present study was carried out to evaluate the morphological similarities or divergence of the traditional rice accessions collected in the same name and catalogued in different accession numbers.

Materials and Methods

The study was conducted at the Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka, during major (*Maha*) season 2012/13 and 2013/14. Twelve *Heeneti* accessions were selected from plant genetic resources centre (PGRC), Gannoruwa, Sri Lanka (Table 1). Seeds collected from PGRC were kept at 50 ⁰C for 5 days to break the dormancy. The seeds were then soaked in 70% alcohol for 2 minutes and washed thoroughly with distilled water. Surface sterilized seeds were dipped in 2% Clorox for 30 minutes and washed the seeds properly with distilled water. Seeds were kept in incubator at 35⁰C for 7 days (Ranawake *et al.*, 2013) under dark conditions and the germinated seeds were planted in soil filled trays.

Table 1: Rice accessions used for the study

Accession Number	Accession Name
5486	Rathuheenati
4992	Rathuheenati
6249	Rathuheenati
3471	Kaluheenati
4621	Kaluheenati
5191	Kaluheenati
4991	Kaluheenati
3851	Kaluheenati
7802	Kaluheenati
3998	Heenati
4618	Heenati
4935	Heenati

Ten days old seedlings were transplanted in 3m long rows spaced 20 cm apart. The seedlings were transplanted at 15cm distance within a row. Varieties were transplanted in a randomized complete block design, with 3 replications, (3 rows per replicate and 20 plants per each row). Data were recorded according to the Standard Evaluation System (SES) for rice, international rice research institute (IRRI) (IRRI, 1988). The data were statistically analysed using the SPSS version 20 software (SPSS inc., 2011). Cluster analysis followed by factor analysis was performed for the agronomic data and dendrogram was created in Ward's linkage.

Results and Discussion

Principle component analysis showed that the first three PCs having Eigen values greater than1 accounted for 81.62% of the total variation. The PC 1, 2 and 3 explained 33.1%, 28.6% and 19.8% variability respectively (Table 2). Plant height, panicle length, yield per plant and harvest index contributed for extremely high PC1 while panicle weight, total grain per panicle, hundred grain weight, yield per plant and biomass contributed for PC2. PC3 has the greater influence of days to flowering, filled grain percentage and biomass (Table 2).

All Heenati rice accessions were grouped into several clusters in the dendrogram (Figure 1). Rathu Heenati-5486 was in a different cluster from other two accessions; Rathu Heenati-6249

Table 2: Variation among rice accessions accounted for first three principle components

Parameter	Principle Component		
	1	2	3
PH	.806	-.084	.387
TNT	-.784	.479	-.197
DF	-.776	.157	.550
FT	-.784	.479	-.197
PL	.717	-.183	.212
PW	.472	.714	.038
TG	.419	.724	-.444
FGP	-.489	-.070	.749
HGW	.482	.820	.185
YLDP	.595	.699	.196
BM	-.447	.580	.516
HI	.708	-.219	.303

Extraction Method: Principal Component Analysis.
PH: Plant height, TNT: Total number of tillers/plant, DF: Days to flowering, FT: Number fertile tillers/plant, PL: Panicle length, PW: Panicle weight, TG: Total Grain per panicle, FGP: Filled grain percentage, HGW: Hundred grain weight per plant (100 gr wt), YLDP: Filled grain weight, BM: Biomass per plant and HI: Harvest index.

and Rathu Heenati-4992 at cluster distance 25. Rathu Heenati-6249 and Rathu Heenati-4992 belonged to different clusters at cluster distance 13. Hence these three Rathu Heenati accessions were different from each other according to their morphological characteristics though they were given the same name.

Six Kalu Heenati accessions were clustered in to two groups at cluster distance 13 in the dendrogram (Figure 1). Kalu Heenati-3471and Kalu Heenati-5191 were in different clusters from other four Kalu Heenatiaccessions (-3851,-7802,-4621,-4991). Kalu Heenati-3471 and Kalu Heenati-5191 were belonged to the same cluster. Therefore, these two accessions were

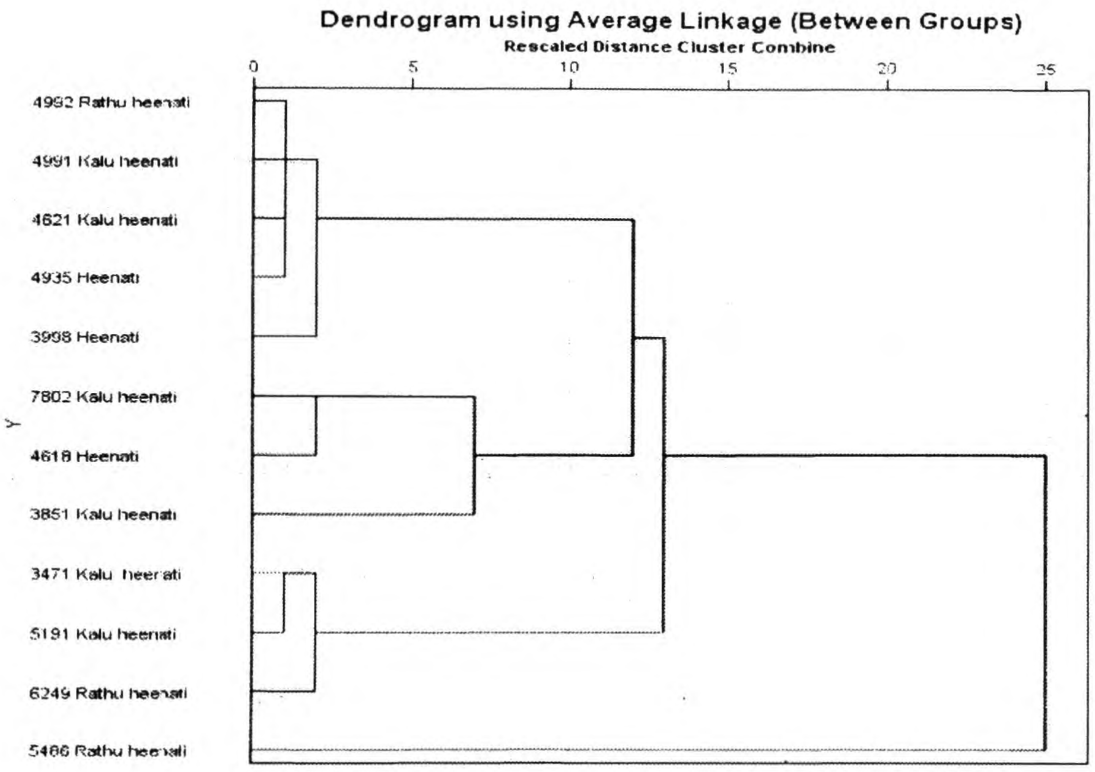

Figure 1: Dendrogram of rice accessions obtained in Ward linkage analysis

morphologically similar from other all Kalu Heenati accessions. Rest of the Kalu Heenati accessions were clustered in to two groups at cluster distance 12. Kalu Heenati-3851 and Kalu Heenati-7802 were clustered in to the same cluster; cluster II. Therefore, these two accessions were morphologically similar from other two Kalu Heenati accessions. Kalu Heenati-4991 and Kalu Heenati-4621 were in the same cluster, cluster I. Therefore, these two accessions were morphologically similar.

Three Heenati accessions were grouped in to two clusters at cluster distance 12. Heenati-4618 was in a different cluster from other two Heenati accessions (-4935, -3998) (Figure 1). Heenati-4935 and Heenati-3998 were belonged to the same cluster. These two Heenati accessions were similar according to their morphological characteristics though they were given different accession numbers.

Rice accessions in Cluster I which consisted of three rice accessions named Rathu Heenati-4992, Kalu Heenati(-4991,-4621) and Heenati(-4935,-3998)consisted of semi-dwarf, low tillering, semi-sterile or highly-sterile accessions. Kalu Heenati-7802 and Heenati-4618in cluster II were semi-dwarf, low or very low tillering, and fertile or semi-sterile. Kalu Heenati-3851 and Rathu Heenati-5486 accessions were grouped in to two different clusters, cluster III and cluster V respectively, where cluster III could be identified as a semi-dwarf, very lowtillering and semi-sterile group and cluster V was a semi-dwarf, low-tillering and semi-sterile group. Kalu Heenati(-3471,-5191) accessions and Rathu Heenati-6249 those belonged to cluster IV were semi-dwarf, low tillering and fertile or highly fertile.

Conclusions

Over 80% of total variance was explained by the resulted principal components. This study indicated that rice with the same cultivar name but in different accession numbers may not always belong to the exact cultivar under which they have been catalogued based on their morphological traits.

Acknowledgement

The authors gratefully acknowledge the financial support of ICGEB/CRP/SRI/113-01and PGRC, Gannoruwa, Sri Lanka for providing the seed materials of all tested rice accessions.

References

IRRI 1988. Standard evaluation system forrice.The International rice testing program. 3rd Edition, the International Rice Research Institute, Los Banos, Philippines.

Lasalita-Zapico FC, Namocatcat JA, and Turner JLC, 2010. Genetic diversity analysis of traditional upland rice cultivars in Kihan, Malapatan, Sarangi province, Philippines using morphometric markers, Philippine Journal of Science, 139 (2):177-180.

Ranawake AL and Hewage MJ 2014a. Correlation analysis of drought, salinity and submergence tolerance in some traditional rice cultivars of Sri Lanka, International

Journal of Scientific and Research Publications,4(7).

Ranawake AL, Amarasinghe UGS and Dahanayake N 2014b. Assessment of allellopathic potential of some traditional rice cultivars in Sri Lanka, International Journal of Scientific and Research Publications,4(7).

Ranawake AL, Amarasingha UGS. and Dahanayake N 2013. Agronomic characters of some traditional rice (*Oryza sativa* L.) cultivars in Sri Lanka, J.Univ.Ruhuna1 (1):3-9.

Seneviniwan M 2010. Indigenous Paddy Varieties and Traditional Knowledge. Economic Review, http://dl.nsf.ac.lk/bitstream/handle/1/14120/ER-36-%2812%29_54.pdf?sequence=2&isAllowed=y Retrieved on 21st June 2014.

Wickramasinghe HAM and Noda T 2008. Physicochemical properties of starches from Sri Lankan rice varieties. Food Science and Technology Research14 (1):49-54.