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Influence of intercropping system on growth and productivity of Garden rue with vegetables in *alfisols* of eastern dryzone of Karnataka under irrigated condition

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Abstract
Garden rue (*Ruta graveolens* L.) is a small evergreen sub shrub, grown as both a medicinal herb and condiment belongs to Rutaceae family. Itis said to relieve gas pains and colic, improve appetite, digestion and promote the onset of menstruation and uteral contractions. However, less information is available on scientific cultivation of Garden rue. The present study was conducted to know the influence of intercropping system on growth and productivity of Gardenrue with vegetables in *alfisols* at College of Horticulture, GKVK, Bengaluru. The experiment comprised of sole crop and intercropped with four vegetable crops (French bean, okra, cluster bean and carrot) spaced at 60X45 cm. The sole crop of gardenrue performed better growth with respect to parameters and fresh herb yieldas well as dry herb yield, while in intercropping systems, cluster bean intercropped with gardenrue recorded the maximum fresh herb and dry herb yield.

Keywords: garden rue, alfisols, intercropping, vegetables

Introduction
Intercropping is the cultivation of two or more crops at the same time in the same piece of land. There has been an increase in grower's interest in adopting intercropping system, as it could reduce management inputs that result in sustainable systems more efficiently using an even potentially replenishing natural resources used during crop production for long term management of farmland. (Allen and Obura, 1983, Altier and Liebman1994) [1, 2]. The advantages of intercropping are risk minimization, effective use of available resources, including labour, increased crop/land productivity, soil conservation and food security
Systematic cultivation of medicinal crops as pure crops is not encouraging asitis uneconomical. In many of the crops as long gestation period, high cost of cultivation, non availability of suitable land, ineffective utilization of natural resources and other production inputs. Large fluctuation in price, low yields and discouraging government policies are other impeding factors (Rao *et al.*, 1996) [10]. Hence most of the farmers are not coming forward to grow medicinal plants in pure stand. This trend hampers the sustainable supply of raw material to the pharmaceutical industry at a reasonable price. This warrants import of raw material from other countries with an out flow of lot of valuable foreign exchange to meet the requirement of domestic pharmaceutical industries.
Under these circumstances, to meet the requirement of vegetables for ever increasing population and to supply the raw material to pharmaceutical industry, the only option is through time and space utilization in agriculture especially under irrigated systems (Sankaran and Rangaswamy, 1990) [11]. One such strategy to increase agricultural output is to go for intensive cropping systems including intercropping systems.
Garden rue (*Rutagraveolens* L.) belongs to the family Rutaceae. It is a small evergreen sub shrub or semi woody perennial which grows to a height of 2-3 ft tall and almost as wide. It is sometimes grown as an ornamental plant in gardens, because of its bluish decorative leaves. It is also grown as both a medicinal herb and as a condiment. In European folk medicine, rue is said to relieve gas pains and colic, improve appetite and digestion and promote the onset of

menstruation and uteral contractions. For this reason, the refined oil of rue has been cited by the Roman historian Pliny the Elder and the gynaecologist Soranus, as a potent abortifacient (inducing abortion).

Inclusion of gardenrue with other routine crops of the farmer's choice or crops in demand or commercial cash crops or crops for subsistence of the farmer of the region will not disturb his normal agricultural practices besides increasing his income.

Materials and methods

The field experiment was conducted at Department of Plantation, Spices Medicinal and Aromatic crops, College of Horticulture, University of Horticultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru, which is situated in Eastern Dry Zone (Zone – 5) of Karnataka, located at an altitude of 930 M above MSL with a latitude and longitude of 12^0 51' North and 77^0 35' East, respectively.

The experiment was conducted in five treatments with four replications statistically in RCB design. In the study we used four vegetables like french bean, okra, cluster bean and carrot along with garden rue. The individual plot size was 4.80m X 2.70m during summer 2015- *Kharif* 2015 in irrigated condition.

Garden rue seedlings were raised in the nursery beds of 3 m length, 1.2 m width and 10 cm height. The seeds were sown on November, 2014 and May, 2015 during first and second season, respectively. During both the seasons garden rue seedlings were transplanted in to poly bags (3x4") filled with a mixture of red soil, sand and FYM (1:1:1) after 20 days of sowing and kept under shade and later transplanted in the main field.

Healthy okra seeds were soaked in water over night. Cluster bean and French bean seeds were treated with Captan @ 2g per kg. French bean, okra and cluster bean seeds were dibbled at 0.5 cm depth. As the seeds of carrot were too small, they were mixed with sand (1:3) and sown in shallow furrows and the rows were covered with soil.

To record observations on growth parameters, five plants were selected randomly in each plot in all the four replications and were labelled. Observations were recordedat30, 60, 90,120 days after sowing orpl anting of the crop as the case may be and at harvest.

The plants were harvested when 50 per cent of them started flowering by cutting the plants at a height of 5 cm from ground level using secature and the harvested herbage was dried under natural shade.

Results and discussion

The results clearly indicated the significant impact of cropping systems on the growth of garden rue during both the seasons (Table 1). The height of garden rue remained almost same during both the seasons. The growth of garden rue was better during *kharif* than the summer season. Maximum plant height was recorded when garden rue intercropped with okra during both the seasons (53.9 and 56.7 cm respectively) which differed significantly from rest of the cropping systems. This might be due to vertical growth habit of garden rue plants in a narrow space available between rows and intercrops and also due to partial shade of okra.

At harvest, maximum number of primary branches was recorded in the sole crop of garden rue (17.2), which differed significantly from rest of the cropping systems tried. This is due to maximum light transmission, space, water and nutrient availability for the sole crop of garden rue. Similar results have been recorded by Rao *et al.* (1986) [9]; Koppalkar (2007) [7]; Chandrakanth (2006) in respect of plant height and number of branches of ashwanagadha in pure stand as compared to intercropped ashwagandha. While, least number of primary branches was recorded in the garden rue + carrot (12.2) intercropping system which was at par with Garden rue +cluster bean (12.9) which can be ascribed to higher competition for light, space, water and nutrition for its growth and development. Similar trend prevailed during second season (*kharif*), with significant differences in number of primary branches at all the growth stages.

Maximum plant diameter (43.9 cm)was recorded in sole crop of garden rue at harvest during summer, which was on par with other intercropping systems such as garden rue + french bean and garden rue + okra (42.5 and 42.1cm respectively). This can be related to more space available for garden rue when grown as sole crop, with higher light transmission causing reduced apical dominance resulting in more number of branches which ultimately increased the plant diameter. During *kharif* season, maximum plant diameter was recorded in sole crop of garden rue (42.8 cm), which was on par with garden rue+ cluster bean and garden rue +okra (42.0 and 41.9 cm respectively) at harvest. These results are in conformity with those of Singh (2008) [11] in patchouli crop when intercropped with legumes and vegetables. Significantly lowest plant diameter was recorded in the garden rue + carrot (38.2cm) intercropping system.

The cropping systems had no influence on days to first flowering and 50 per cent flowering in garden rue during both the cropping seasons (Table1).

The fresh and dry weight of leaf, stem and flowers and the whole plant of garden rue was maximum when the crop was raised as a sole crop during both the seasons (Table 2). During summer, the highest leaf fresh weight was recorded in sole crop of garden rue (240.7 g plant^{-1}).Similarly, significantly the highest fresh weight of stem and flowers was recorded in sole crop of garden rue (229.2 g plant^{-1}). The total fresh weight of plant was significantly higher in sole crop of garden rue (469.9 g plant^{-1}) over other combinations. The reason for increased fresh weight of leaf, stem and whole plant in sole crop of garden rue was due to the application of recommended dose of fertilizer to all crops when grown in pure stand, but not to intercrops (vegetables) and other possible reason could be lower plant density in sole cropping as compared to intercropping systems. Similar results have been obtained by Rao *et al.* (1986) [9]; Koppalkar (2007) [7] and Chandrakanth (2006) in pure ashwanagadha as compared to intercropped ashwagandha. Almost similar trend prevailed during *kharif* season also.

During summer, garden rue as a sole crop recorded highest leaf dry weight (70.0 g plant^{-1}). Similarly, the highest dry weight of stem +flowers per plant in garden rue was recorded in sole crop (69.2 g plant^{-1}), which was significantly higher than other cropping systems. The highest plant dry weight (139.2 g plant^{-1}) was in sole crop of garden rue. Similar observations were made during *kharif* season, also, wherein, significant differences were noted in respect of dry weight of leaf, stem+flowers and whole herb of garden rue when raised as a sole crop (77.6, 89.9, and 167.5 g plant^{-1} respectively).

Significant differences were recorded in respect of fresh herb yield of garden rue due to intercropping systems in both the seasons (Table 3). The fresh herb yield was higher in summer than in *kharif*. In summer, significantly higher fresh herb yield was recorded in sole crop of garden rue (17.01 t ha^{-1}). During *kharif* also, maximum fresh herb yield was obtained in

sole crop of garden rue (13.9 t ha^{-1}). This can be attributed to increased number of primary branches, plant diameter and fresh weight of leaf, stem and whole plant. Rao *et al.* (1986) [9]; Koppalkar (2007) [7] and Chandrakanth (2006) have also reported similar results in ashwanagadha.

Intercropping systems caused significant differences in respect of shade dried herb yield of garden rue during both the seasons. In summer and *kharif* crop, higher dry herb yield was recorded in sole crop of garden rue (4.77 and 6.2 t ha^{-1}) respectively, which differed significantly from other treatments. The pooled data indicated that, dry herb yield was maximum in sole crop of garden rue with 5.48 tonnes per hectare, which was significantly higher than the rest of the treatments, which can be related to higher number of primary branches, plant diameter, dry weight of leaf, stem and whole plant in sole crop of garden rue.

Table 1: Different growth characters of garden rue as influenced by intercropping systems

Treatments	Summer, 2015 (At final harvest)					*Kharif*, 2015(At final harvest)				
	Plant height (cm)	No of primary branches	Plant diameter (cm)	Days for first flowering	Days for 50 % flowering	Plant height (cm)	No of primary branches	Plant diameter (cm)	Days for first flowering	Days for 50 % flowering
T $_{1}$- Garden rue	45.3	17.2	43.9	97.3	144.0	48.9	14.3	42.8	97.0	137.7
T $_{2}$- Garden rue + French bean	48.5	14.1	42.5	98.3	143.7	51.3	9.8	33.5	97.0	137.0
T $_{3}$- Garden rue + Okra	53.9	13.6	42.1	95.0	141.7	56.7	12.4	41.9	96.3	135.3
T $_{4}$- Garden rue + Cluster bean	47.0	12.9	39.3	96.0	141.0	53.5	11.7	42.0	95.3	134.3
T $_{5}$- Garden rue + Carrot	44.7	12.2	38.2	99.0	143.7	50.5	9.7	39.2	96.3	134.0
SEm±	0.4	0.4	1.0	1.4	0.7	0.8	0.3	0.6	1.0	1.4
CD at 5%	1.4**	1.3**	3.2**	NS	NS	2.5**	1.1**	2.1**	NS	NS

** Significant at 1 %

Table 2: Fresh and dry weight (g plant^{-1}) of different parts of garden rue at final harvest as influenced by intercropping systems

Treatments	Fresh weight							Dry weight						
	Summer, 2015			*Kharif*, 2015				Summer, 2015			*Kharif*, 2015			
	Leaves	Stem +flowers	Total	Leaves	Stem +flowers)	Total	Pooled fresh weight	Leaves	Stem +flowers	Total	Leaves	Stem +flowers	Total	Pooled dry weight
T $_{1}$- Garden rue	240.7	229.2	469.9	191.7	222.2	413.9	441.6	70.0	69.2	139.2	77.6	89.9	167.5	153.4
T $_{2}$- Garden rue + French bean	208.0	172.2	380.2	143.5	170.3	313.7	347.0	68.7	56.6	125.3	58.1	68.9	127.0	126.2
T $_{3}$- Garden rue + Okra	197.3	185.5	382.8	152.3	173.4	325.7	354.3	56.5	57.7	114.2	61.7	70.2	131.8	123.1
T $_{4}$- Garden rue + Cluster bean	168.0	171.0	339.0	151.7	197.7	349.4	344.9	56.8	49.6	106.4	61.4	80.0	141.4	124.2
T $_{5}$- Garden rue + Carrot	162.3	169.3	331.6	105.7	146.3	252.0	291.8	54.5	46.9	101.3	42.8	59.2	102.0	101.2
SEm±	13.5	12.4	19.2	15.0	14.7	24.1	17.0	3.7	3.4	7.6	6.1	4.4	9.6	2.6
CD at 5%	44.0**	40.4**	62.6**	48.9**	47.9**	78.5**	55.4**	12.2**	11.2**	24.7**	19.8**	14.3**	31.5**	8.6**

** Significant at 1 %

Table 3: Fresh and dry herb yield (tha^{-1}) of garden rue as influenced byintercropping systems

Treatments	Fresh herb yield			Dry herb yield		
	Summer, 2015	*Kharif*, 2015	Pooled mean	Summer, 2015	*Kharif*, 2015	Pooled mean
T $_{1}$- Garden rue	17.01	13.9	15.48	4.77	6.2	5.48
T $_{2}$- Garden rue + French bean	13.48	10.5	11.98	4.10	3.6	3.84
T $_{3}$- Garden rue + Okra	12.87	11.1	11.97	4.27	3.7	3.99
T $_{4}$- Garden rue + Cluster bean	14.57	11.8	13.21	4.30	4.3	4.32
T $_{5}$- Garden rue + Carrot	13.22	8.7	10.95	3.95	3.1	3.53
SEm±	0.57	0.8	0.34	0.14	0.2	0.14
CD at 5%	1.87**	2.6**	1.10**	0.45**	0.8**	0.45**

** Significant at 1 %

Conclusion

Gardenrue crop performed well in both the seasons indicated that, the sole crop of garden rue recorded the maximum values for growth and yield parameters such as fresh weight of whole plant (441.6 g plant^{-1}), dry weight of whole plant (153.4 g plant^{-1}), fresh herb yield (15.48 t ha $^{-1}$) and dry herb yield (5.48 t ha^{-1}). The garden rue intercropped with cluster bean recorded the maximum fresh herb and dry herb yield (13.21 and 4.32 t ha^{-1}, respectively).

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