Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP3: 443-446

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National conference on "Conservation, Cultivation and Utilization of medicinal and Aromatic plants" (College of Horticulture, Mudigere Karnataka, 2018)

Integrated nutrient management in garden rue (*Ruta graveolens* L.)

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Abstract
Garden rue (*Ruta graveolens* Lin.) belonging to the family Rutaceae is one of the important medicinal plants whose whole herb is a rich source of rutin, used to cure various ailments like kapha, vata, fever, flatulence and fresh herb acts as scorpion and insect repellent. Rue oil is used for the preparation of perfumes and many products like rue gel, rue tea and capsules. Indiscriminate use of chemical fertilizers and pesticides will have deteriorating effect on physical, chemical and biological properties of the soil. It is pertinent to increase the productivity of herb and medicinally important chemical constituents without hazardous chemical residues through integrated nutrient management. A field experiment was conducted during *kharif*, 2017-2018 at College of Horticulture, UHS Campus, GKVK, Bengaluru to study the effect of organic and inorganic sources of nutrients on growth and yield of garden rue. Five organic sources (Farm yard manure, *Azospirillum*, *Azotobacter*, AM and Arka Microbial Consortium) were applied singly and in combination with the recommended dose of inorganic fertilizers and compared with the control. Among the different treatments, 75 per cent RDF + *Azotobacter* + *Azospirillum* + AM @ 10 kg per ha recorded maximum plant height (62.60 cm), number of branches (16.40), stem girth (17.48 mm), early flowering (126.02 days) and fresh weight per plant (239.78 g), fresh weight per hectare (19.38 t). Hence, it is possible to increase both productivity and quality of raw material by integrated nutrient management practices in garden rue.

Keywords: *Ruta graveolens*, INM, organic manures, AM, biofertilizers

Introduction
Garden rue belongs to family Rutaceae is used in traditional system of medicine world-wide, which is commonly known as Rue, and Sadab in Hindi. Although, it is native to Mediterranean region, it is distributed throughout the world. Garden rue is a small evergreen sub-shrub or semi woody perennial grows to a height of 0.6-0.9 m. The stems become woody near the base, but remain herbaceous nearer the tips. Leaves measured 7.6 to 12.7 cm long and are dissected pinnately into oblong or spoon shaped segments. They are somewhat fleshy and usually covered with a powdery bloom. The sea green foliage has a strong, pungent, rather unpleasant scent when bruised. The paniculate clusters of small yellow flowers appear in midsummer, and are seen above the foliage and often covering most of the plant (Zargari, 1988) [19]. Extracts from R. graveolens have been used as an antidote for toxins such as snake and scorpion venoms (Sallal and Alkofahi, 1996) [14] Garden rue has been used as a folk medicine for treatment of various conditions such as kapha, vata, fever, flatulence, eye problems, rheumatism, dermatitis, pain and many inflammatory diseases (Ratheesh and Helen, 2007) [13]. Garden rue is rich in rutin, which act as a venotonic and capillary protector. Rutin helps to increase visual sharpness and alleviates other visual problems and it was used against edema, thrombogenesis, inflammation, spasms and hypertension (Miguel, 2003) [10]. The rue oil is spasmolytic, anti-inflammatory and antihistaminic and is a vermifuge and is used in the preparation of perfumes and many products like rue gel, rue tea and capsules (Mansour *et al*. 1989) [9]. Though the production of medicinal plants can be increased by supplying the nutrients through chemical fertilizers alone, but continuous use of them on long-term basis may lead to the degradation of the soil quality and also affect potency. In order to increase the quality of crops especially, medicinal and aromatic plants (MAPs), organic manuring is more acceptable than chemical fertilizers. However, complete replacement of inorganic fertilizers by

the organic manures is not advisable owing to constraints such as low nutrient concentration, timely availability, in required quantity at a reasonable cost. In this endeavour, a blend of organic, inorganic and bio-fertilizers is important not only for increasing the yield but also for sustaining soil health and maintaining favourable ecological conditions on long term basis to keep the soil as a permanent productive asset.

Material and Methods

A field experiment was conducted during *kharif*, 2017-2018 at the Department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, UHS Campus, GKVK, Bengaluru. The experimental site was a fairly level land with red sandy clay loam soil of fairly uniform fertility status and belonged to the order of alfisols. The experiment was conducted in randomized complete block design (RCBD) with twelve treatments replicated thrice as fallows. T_1: Control (RDF 150:50:50 kg N:P:K and 10 tons FYM per ha), T_2: 75% RDF through fertilizers + 25% N through FYM, T_3: 50% RDF through fertilizers + 50% N through FYM, T_4:75% RDF + AM @ 10 kg/ha (AM application at nursery stage), T_5:75% RDF + *Azospirillum* @ 10 kg/ha, T_6:75% RDF + *Azotobacter* @ 10 kg/ha, T_7:75% RDF + *Azospirillum* + AM @ 10kg/ha (AM application at nursery stage), T_8:75% RDF + *Azotobacter* + AM @ 10 kg/ha (AM application at nursery stage), T_9:75% RDF + *Azospirillum* + *Azotobacter* + AM @ 10 kg/ha (AM application at nursery stage), T_{10}:50% RDF + *Azospirillum* + *Azotobacter* + AM @ 10kg/ha (AM application at nursery stage), T_{11}: AM + *Azospirillum* + *Azotobacter* @ 10 kg/ha (AM application at nursery stage), $T1_2$: Arka Microbial Consortium @ 8 kg/ha. Healthy garden rue seeds were collected from the Department of Horticulture, University of Agricultural Sciences, Bengaluru. Seeds were soaked in water over night before sowing, for better and early germination. Seeds were mixed with sand and sown in the well prepared raised beds at 10 cm apart and covered with the sand and light watered daily. Seeds started germinating within 10 days and 90 per cent germination was observed within 20 days. Two per cent of urea spray was given at 40 and 50 days after sowing for better growth and development. Fifty five days old seedlings were transplanted in the experimental plots at a spacing of 40 cm between rows and 30 cm between the plants in the evening hours. The plots were irrigated immediately after transplanting and thereafter, regular irrigation was given at an interval of 3-4 days depending upon the soil moisture and weather conditions. The organic manure (FYM) was applied 15 days prior to transplanting of seedlings in the main field. The fertilizers were applied in the form of straight fertilizers such as urea, single super phosphate and muriate of potash. Of these, 50% N along with full dose P_2O_5 and K_2O were placed in furrows as basal application. The remaining 50 per cent nitrogen was applied as top dressing after 45 days of transplanting. Biofertilizers were applied 15 days after transplanting. Plots were kept weed free throughout the growing period by weeding at regular intervals. The crop was harvested five months after transplanting at half flowering stage, as it contains maximum percentage of active principles at this stage. While harvesting the whole plant was cut at 4-5 cm above the ground level with the help of a sharp sickle. Herb was separated and dried under partial shade for 15 days. The data on growth and yield parameters were subjected to Fisher's method of analysis of variance (ANOVA) as outlined by Sundararaj *et al*. (1972) [16].

Results and discussion

The vegetative growth parameters differed significantly among the different treatments at all the stages of crop growth. (Table I.) Application of 75 per cent recommended dose of fertilizers + *Azospirillum* + *Azotobacter* + AM @ 10 kg per ha resulted in maximum plant height (62.60 cm), stem girth (17.48 mm), primary branches (16.40). This results were at par with the 50% RDF + *Azospirillum* + *Azotobacter* + AM @ 10 kg/ha. This might be due to the fact that biofertilizers have a synergistic effect on the plant and supports the vegetative growth (Balakumbagan *et al*. 2005) [2] and also known to improve the physical and chemical health of soil apart from contributing to the nutrient pool (Tiessent *et al*. 1994) [17]. The application of *Azotobacter, Azospirillum* which fix the nitrogen and nitrogen being the main constituent of protein and nucleic acids, enzymes, energy molecules (ATP and NADP), help in cell division, cell enlargement, production of growth promoting substances like vitamin B, Indole acetic acid, GA. (Fayez *et al*. 1985) [5]. AM (*Arbuscular Mycorrhizae*) is a P mobilizing fungi which mobilize the unavailable form P and help in the root development. These findings were in line with the findings of Manjunatha *et al*. (2002) [8] in patchouli, Mohanchandra (2003) [11] in *Solanum nigrum*, Ajimoddin *et al*. (2005) [1] in sweet basil, Balakumbahan *et al*. (2005) [2] in *Phyllanthus amarus* and Kalyanasundaram *et al*. (2008) [7] in sweet flag. Least vegetative parameters *viz* plant height (46.91 cm), stem girth (10.82 mm), primary branches (11.22) were observed with 50 per cent RDF through fertilizers + 50 per cent N through FYM. This might be due to slow release of nutrients resulted in lower uptake of nutrient by the plant.

The data on days to first flower bud appearance, 50 per cent flowering as influenced by combination of bio inoculants, inorganic fertilizers and organic mannure are presented in Table II. Plants received 75 per cent RDF + biofertilizers flowered early and took significantly least number of days to 50 per cent flowering (126.02). These results are at par with that of plant received 50% RDF + biofertilizers. The highest number of days to 50 per cent flowering (145.45) was recorded with plants supplemented with 50 per cent RDF through fertilizers + 50 per cent N through FYM. The earliness in bud initiation in bio fertilizer-inoculated plants may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinin to the axillary buds, resulting in breakage of apical dominance. Ultimately, this has resulted in a better sink for faster mobilization of photosynthates and early transformation from vegetative to reproductive phase. These results were in line with the findings of (Vasanthi, 1994) [18] in jasmine, (Chandrikapure *et al*. 1999) [4] in marigold and (Gayathri *et al*. 2004) [6] in limonium.

The data on yield parameters as influenced by combination of bio inoculants, inorganic fertilizers and organic mannure are presented in Table III. Plants received 75 per cent RDF + biofertilizers recorded highest fresh weight per plant (239.78 g) and per ha (19.38 ton) and dry weight per plant (74.54 g), per ha (6.21 tons) fallowed by plants supplemented with the 50 per cent RDF +biofertilizers. The increased yield is mainly related to positive correlation between yield contributing characters and better vegetative growth of plants. These characters were greatly influenced by the balanced nutrient application and their availability. *Azotobacter* and *Azospirillum* in addition nitrogen fixation they facilitate better accumulation of photosynthates, which consequently increased the yield. The biofertilizers increase the uptake of

trace elements and increases the chlorophyll and translocation of photosynthates and growth promoting substances. These finding were in conformity with those of Shelke *et al*. (2001) [15] and Bhilare (2002) [3] in forage crop and Pal (2002) [12] in brahmi. Yield parameters such as yield per plant (169.47 g), per ha (12.79 ton) and dry weight per plant (39.67 g), per ha (3.00 tons) were least in plants received 50 per cent RDF + 50 per cent N through the FYM. This might due to slow release of nutrients which resulted in lower uptake of nutrient by the plant.

Conclusion

It could be reasonably inferred that the application of 75% RDF + biofertilizers resulted in higher benefit towards crop growth and herbage yield as compared to application of only chemical fertilisers in alfisols of Bangalore. Application of bio fertilizer with inorganic fertilizer significantly increased the growth and yield parameters of garden rue as compared to their sole application. Looking in to the problem of over mining of the soil due to intensive cropping, the most appropriate proposition will be to adopt integrated nutrient management comprising inorganic fertilizer and organic manures via-a-vis bio fertilizer. This maintains soil health and alleviate the inorganic fertilizer mediated environmental problems.

Table 1: Effect of integrated nutrient management practices on growth parameters of garden rue at harvest

S. No	Treatments	Plant height (cm)	Stem girth (mm)	Number of primary branches
1	T_1	53.39	13.63	13.70
2	T_2	51.56	13.34	13.23
3	T_3	46.91	10.82	11.22
4	T_4	51.71	14.54	13.54
5	T_5	52.89	15.02	14.36
6	T_6	53.23	14.76	14.35
7	T_7	54.90	15.09	14.43
8	T_8	56.85	14.48	14.57
9	T_9	62.60	17.48	16.40
10	T_{10}	60.57	15.84	15.56
11	T_{11}	49.74	14.67	11.57
12	T_{12}	47.35	13.44	11.25
S. Em ±	-	1.91	0.68	0.49
CV %	-	6.19	8.16	6.20
CD at 5%	-	5.60	1.99	1.44

Table 2: Effect of integrated nutrient management practices on reproductive parameters of garden rue

S. No	Treatments	Days to first flowering	Days to 50% flowering
1	T_1	116.33	140.78
2	T_2	118.00	139.71
3	T_3	121.67	145.45
4	T_4	117.00	138.71
5	T_5	115.00	138.26
6	T_6	114.67	135.17
7	T_7	115.67	136.34
8	T_8	117.33	138.43
9	T_9	104.67	126.02
10	T_{10}	112.33	136.03
11	T_{11}	117.67	140.32
12	T_{12}	116.33	140.99
S. Em ±	-	2.15	2.39
CV %	-	3.25	3.00
CD at 5%	-	6.31	7.01

Table 3: Effect of integrated nutrient management practices on yield parameters of garden rue

S. No	Treatments	Fresh weight (g/plant)	Dry weight (g/plant)	Fresh weight (t/ha)	Dry weight (t/ha)
1	T_1	187.01	46.11	14.75	3.69
2	T_2	183.70	44.77	14.15	3.22
3	T_3	169.47	39.67	12.77	3.00
4	T_4	185.27	48.55	14.94	3.86
5	T_5	198.01	49.34	16.07	3.88
6	T_6	202.36	47.44	16.20	3.75
7	T_7	199.26	49.98	16.32	3.88
8	T_8	208.91	56.30	16.95	4.43
9	T_9	239.78	74.54	19.38	6.21
10	T_{10}	223.52	64.40	18.06	5.05
11	T_{11}	179.00	45.46	14.57	3.51
12	T_{12}	173.55	41.69	13.95	3.16
S. Em ±	-	9.14	2.48	0.70	0.19
CV %	-	8.09	8.49	7.68	8.41
CD at 5%	-	26.82	7.29	2.04	0.57

Fig 1: General view of the experimental plot

Fig 2T_9: 75% RDF + *Azospirillum* + *Azotobacter* + AM @ 10 kg/ha

Fig 2T_9: 75% RDF + *Azospirillum* + *Azotobacter* + AM @ 10 kg/ha

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