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Evaluation of indigenous rose varieties as intercrop under coconut plantation in India

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ABSTRACT

Rose (Rosa × hybrida L.) as an intercrop in coconut plantation under tropical wet climate at Kasaragod district of Kerala state in India using 10 Indian cultivars including Hybrid Tea and Floribunda groups were grown under 3 years and 52 years old coconut plantations separately. The performance of roses was assessed based on their survival percentage, vegetative and reproductive growth, pest, and disease incidence. Among all genotypes, the highest plant survival (83.8%) was observed in Damask rose, followed by cultivars Rose Sherbet, Arunima and Pusa Arun with 79.1%, 73.8% and 71.9%, respectively. Superior vegetative growth was noticed in Damask rose, Pusa Arun, Ashwini, and Arunima genotypes. In almost all the cultivars, flowering was noticed during February-March and October-November except for Damask rose, where maximum flowering was observed only during the February-March months. The average number of flowers harvested from a plant in a season ranged from 15 (Abhisarika) – 43 (Arunima) in different tested varieties. Pest and disease incidence observed was 19% -53% and 7% -25%, respectively, in different varieties under both plantation groups. Between both types of coconut plantation, superior growth and flowering were noticed in roses grown under young plantation (3 years) compared to an old coconut plantation (52 years). The benefit-cost ratio (BCR) of rose as intercropping with coconut was found to be 1.38 with an internal rate of return (IRR) of 22 per cent as against 1.24 and 14% without intercropping.

Keywords: *Rosa × hybrida* L., Coconut, Intercropping, Tropical wet climate

INTRODUCTION

Rose (*Rosa × hybrida* L.) is one of the best profitable floricultural crops and demand for this flower exists everywhere irrespective of the climate and geographical location. Besides being popular for its attractive flowers, roses are also known to be one of the most difficult flowers to grow as they need specific climatic conditions for its optimal growth and flowering. Roses thrive well in temperate and subtropical conditions of the world, relatively prefers mild climates. Montanetemperate climatic zone (Himalayans) is home for several wild roses in India. In addition to wild genotypes, there are a number of modern groups of roses that grow well in this region. Central and southern region of India are major agro-climatic zones having tropical wet and dry, tropical wet and semi-arid and arid climate. Within these regions, rose diversity is seen only in some of the hilly and mild climatic zones. Commercial cultivation of modern roses is found to be difficult in these tropical regions due to extremity in weather conditions. However, some specific cultivated genotypes such as 'Kakinada Red', 'Local Pink, 'Local White' and a wild species like *R. leschenaultiana* thrives well under tropical climate. But these are suitable only to produce loose flowers having minimal vase life.

Western coast of southern peninsular India, certain parts of North- Eastern India and Andaman and Nicobar Islands represent tropical wet or tropical monsoon type climate. This climate type is characterized with two peculiar seasons i.e., dry, when temperature reaches its maximum during summers and wet when monsoon makes their seasonal rounds with heavy downpour and thunderstorms. This climate is suitable for coconut-based cropping systems. The adoption of coconut based multiple cropping system had emerged as a viable option for enhancing the economic returns of coconut growers. Several researchers have taken up experiments with a variety of flower crops for checking their suitability as an intercrop under coconut plantations for gaining sustainable additional income (Ghosh *et al.*, 3). Present study was taken up to evaluate the performance of indigenously bred rose cultivars as an intercrop under two different age groups of coconut plantations in a tropical wet climate of India.

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MATERIALS AND METHODS

The experiment was carried out in research farm at Indian Council of Agricultural Research- Central Plantation Crops Research Institute (ICAR-CPCRI), Kasaragod, Kerala, India during November 2018 to December 2019. The site is geographically situated at 12° 30' N latitude and 75°00' E longitude with an altitude of 10.7 m above mean sea level. The climate of the selected experimental area was typified as 'tropical wet climate or tropical monsoon climate' (Peel *et al.*, 10). The average maximum and minimum temperatures recorded during experiment were 31.7˚C and 22.2˚C, respectively. Total rainfall received during the experimental duration was 4098 mm. Also, relative humidity of 71.9% (FN) and 68.36% (AN) with mean evaporation of 3.53 mm day^{-1} was recorded. The soil type of the experimental site was well-drained, coarse-textured red sandy loam. Electrical conductivity, organic carbon content and pH values of the soil of the experimental site were 0.0032 S/m, 0.93% and 5.72, respectively.

Eight popular rose cultivars belonging to Hybrid Tea (Ashwini, Pusa Arun, Abhisarika and Soma), Floribunda (Arunima, Pusa Manhar, Pusa Muskan, and Shola) groups (grafted on *Rosa multiflora* rootstock material), and two self-rooted fragrant cultivars *viz*., Rose Sherbet, Damask rose were selected for intercropping experiment. The materials were procured from the ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi. Two types (i.e., 3 years and 52 years) of pre-established coconut orchards (with West Coast Tall variety) planted at a spacing of 9 m × 9 m were selected for intercropping experiment with rose (*Rosa* spp. L.). Experiment was laid out in Randomized Completely Block Design (RCBD) with four replications and 10 cultivars. For each replication, 10 plants were chosen. Roses were accommodated on prepared beds (2 m × 7 m) with three rows having spaced of 1 m × 1 m between the plants and rows. A total of 15 rose plants were accommodated on each bed surrounded by four coconut palms. Recommended dose of fertilizers was applied to the plants after testing nutrient status of the experimental soil. Cultural practices such as, weeding, hoeing, desuckering and removal of sprouted rootstock shoots were practised regularly at a minimum of 30 days interval. Plant protection measures were taken to reduce the incidence of pests and diseases. Pruning was performed after 60 and 300 days after planting (after cessation of monsoon) to allow flowering.

Different plant growth and flowering parameters, percent plant survival, Incidence of pests and diseases were recorded during two flowering seasons, i.e., 120 DAP and 330 DAP. Average nut yield of the palms (nut yield /palm) was also recorded before and after initiation of the experiment to verify the influence of intercrop rose on coconut yield. Leaf Area Index (LAI) in intercropped rose cultivars and PAR (Photosynthetically Active Radiation) values (μ mol /m^2 s) between coconut plantations were calculated using CI-100 digital plant canopy imager (CID Co., Ltd). Chlorophyll and carotenoid contents of the leaves were measured using DMSO method (Hiscox and Israelstam, 4). Total soluble sugars and total phenols from the rose leaf samples were estimated by following phenol sulphuric acid method (Dubois *et al*., 2) and folins ciocalteus method (Bray and Thorpe,1), respectively.

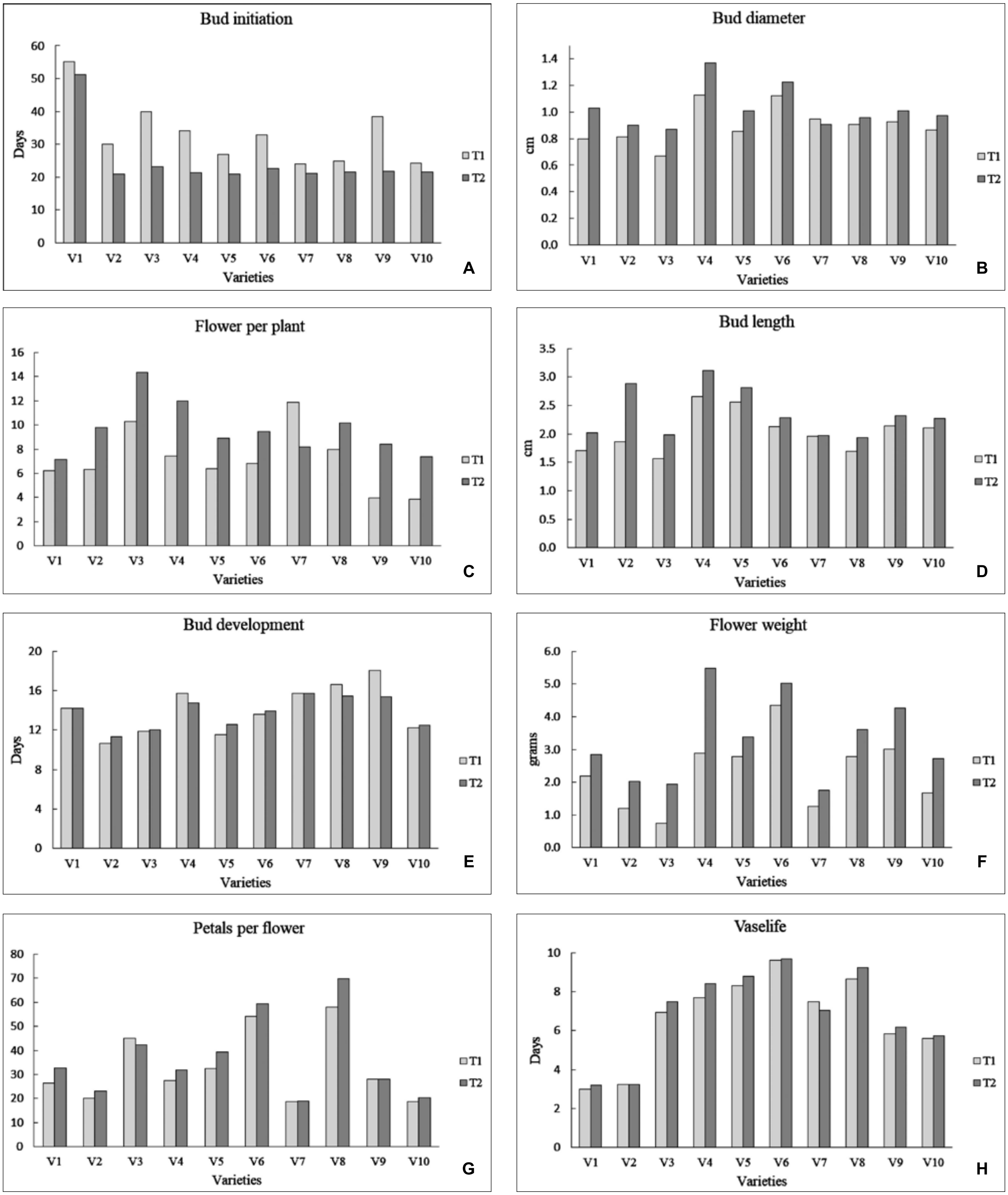
The data were statistically analysed using the statistical software SPSS package 21.0 (IBM Corp, Armonk, NY, USA). The mean values of different parameters were analysedusing RCBD (Randomized Completely Block Design) with two treatments and four replications. Differences in parameters were compared using analysis of variance (ANOVA) to test the significant variation among the cultivars and treatments. Test of significance was determined by the magnitude of the F value (P = 0.05). Treatment means were separated by Tukey's honest significant difference test. Capital productivity analysis was carried out to verify the economic befit of 'coconut + rose' intercropping system.

RESULTS AND DISCUSSION

Among all intercropped rose cultivars, Damask rose recorded greater survival percentage i.e., 83.8%, which was followed by cultivars Rose Sherbet (79.1%), Arunima (73.8%) and Pusa Arun (71.9%), respectively (Fig.1J). However, cultivars Soma and Pusa Manhar recorded 55.8%, and 56% survival (Fig.1J). No significant differences on survival percentage of rose as intercropping could be observed between juvenile and aged plantations. However, majority of the cultivars used in the experiment exhibited medium to low survival rate, which could be due to heavy rainfall experienced in this region during monsoon. The extreme wet conditions encourage weed growth, which gives a tough competition for the main crop as well as intercrop; also leaches soil nutrients, especially nitrogen. High humidity is another characteristic feature of this climate that favours the growth of mould and bacteria in soil and plants which ultimately affects the crop growth negatively.

Plant growth type and growth habit of rose genotypes were found same under both the plantations except for two Floribunda cultivars Shola and Arunima. Arunima and Shola varieties grown under aged coconut plantation with more shade exhibited luxurious vegetative growth and spreading behaviour than plants grown under less shade. Though greater volume of vegetative growth was noticed under aged plantation with partial shade, flower yield was more under young coconut plantation with more light. Whitcomb (13) also reported better growing ability of Floribundas under partial shady areas of garden.

Plants grown under young coconut plantation showed more plant height, a greater number of



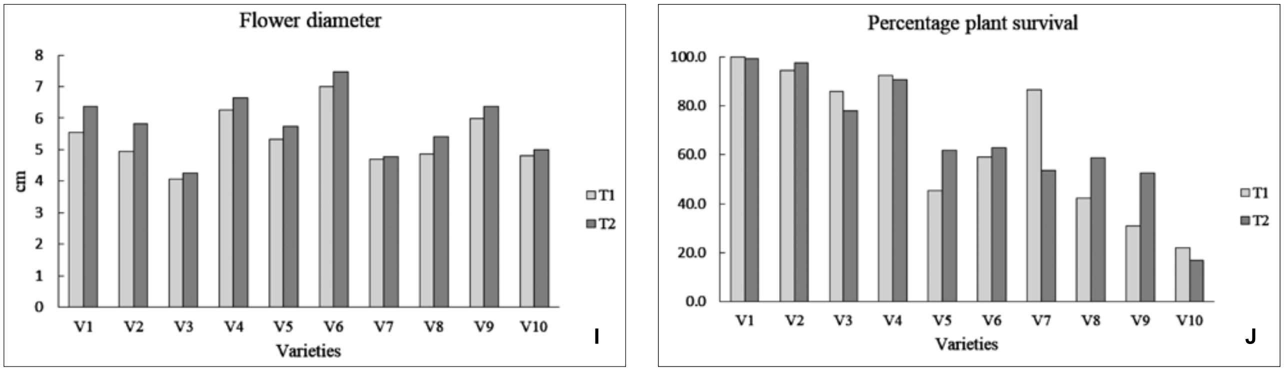


Fig. 1. Graphical illustrations showing different flowering parameters and its performance among inter cropped rose vartieties between adult (T1) and juvinile (T2) coconut plantations. (A). Days taken for bud initiation after pruning (B). Flower bud diameter, (C).Average number of flowers /plant/ harvest; (D) Flower bud length; (E). Number of days taken for flower development; (F). Flower weight; (G). Number of Petals/flower; (H).Vaselife of the flowers on plant; (I).Flower diameter; (J).percent of plant survival under two plantation types

primary and secondary branches and high girth of the primary and secondary shoots than plants grown under old coconut plantation (Table1). The better growth behaviour observed under young coconut plantation could be due to the availability of additional sunlight light than the other. The PAR (Photosynthetically active radiation) values observed under old and young coconut plantation are 689.9 μ mol /m^2 s and 768.4 μ mol /m^{2}s, respectively (Fig.2). Due to less extension of the coconut crown in young palms (3 years old), light availability was more in the interspaces of the palms. While in old plantation (52 years), light interception through crown was partial due to the more coverage of the crown area. According to Magat (6) light transmission in 40 years old coconut garden with spacing of 9 m × 9 m (square planting) was around 47% and this light is enough for growing number of flower crops. The uniformity

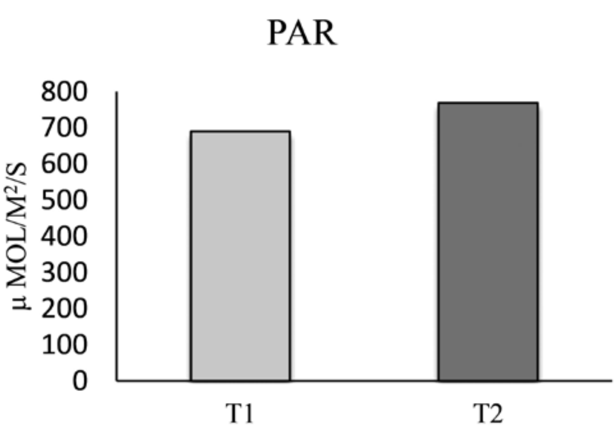


Fig. 2. (a). Avilability of Photosynthetically Active Radiation under both types of coconut plantation T1- old coconut plantation (52 yr), T2-Juvinile coconut plantation between (3 yrs)

in availability of good amount of light across the seasons (dry and monsoon seasons) in the inter row spaces of young coconuts might have influenced the plants to gain more of vegetative growth; this was evidenced by slightly higher values of chlorophyll values. Among studied rose cultivars, Damask rose exhibited better plant growth characteristics with higher plant height and good number of primary, secondary branches, shoot girth, which was followed by varieties Pusa Arun and Ashwini (Table1).

All most all the varieties of roses intercropped under coconut plantation were flowered during both the seasons (spring and winter) except Damask rose. Under temperate and sub-tropical regions, the damask rose bears flowers during only one season (April-May) within a span of 25-30 days. Similar flowering habit was noticed in this genotype under tropical climate too in experimental area. Among intercropped cultivars, differences were observed for flower bud initiation under both types of coconut plantations. Flower bud initiation was found to be rapid in roses grown under young coconut plantation as compared to old (Fig.1A). Similarly, flower development was also faster in roses grown under higher light intensity as compared to the old. Light intensity (Zieslin and Mor, 14) and temperature (Rezazadeh *et al.*, 11) influences the flowering time and development in ornamentals. Availability of good amount of vegetative growth along with higher light and temperatures might have accelerated the rapid flower bud initiation and development in roses grown under young plantation as compared to old. The average number of harvestable flowers/ plants during peak flowering season of the plants varied from 4.74 (Abhisarika) to 14.47 (Arunima) in different varieties (Fig.1C). Maximum three harvests were taken from

Table 1. Vegetative growth parameters of inter crop Rose (*Rosa* × *hybrida* L.) between treatments and cultivars (V's)

		Plant ht. (cm)	Inter nodal length (cm)	No. of Primary shoots	Girth of Primary shoot (cm)	No. of Secondary shoots	Girth of Sec. shoot (cm)	Length of sec. shoots (cm)	Mean leaf length (cm)	Mean leaf width (cm)	Avg. no. of leaves per sec. sht.
V1	T1	107.8±6.6	2.8±0.10	5.2±0.07	0.68±0.05	6.8±0.18	0.25±0.01	25.6±5.5	8.5±0.42	7.1±0.53	10.9±1.1
	T2	142.9±8.6	3.6±0.20	6.5±0.10	0.95±0.05	12.2±0.36	0.35±0.05	43.1±4.72	11.1±0.4	7.7±0.29	14.9±2.3
V2	T1	39.8±2.3	2.3±0.04	3.0±0.10	0.46±0.01	4.8±0.39	0.23±0.01	19.2±0.93	8.1±0.21	6.6±0.30	7.7±1.9
	T2	46.5±2.3	2.7±0.11	3.02±0.2	0.55±0.03	7.8±0.04	0.29±0.03	19.9±3.66	8.34±0.13	6.7±0.16	8.5±0.9
V3	T1	57.0±3.0	1.7±0.04	5.3±0.25	0.6±0.03	9.5±0.74	0.21±0.02	10.3±1.14	6.9±0.29	5.1±0.09	5.6±0.3
	T2	58.6±1.7	2.2±0.04	4.5±0.20	0.64±0.03	12.6±1.24	0.21±0.01	11.9±0.3	6.8±0.27	5.3±0.22	6.7±1.1
V4	T1	65.9±3.6	3.3±0.08	2.5±0.06	0.62±0.04	5.3±0.7	0.33±0.01	21.1±1.58	9.4±0.23	7.3±0.14	8.4±1.2
	T2	79.2±3.7	3.5±0.06	2.4±0.20	0.87±0.02	8.04±0.2	0.37±0.04	38.7±2.5	10.6±0.09	8.2±0.15	11.7±1.1
V5	T1	54.4±0.5	2.7±0.19	2.5±0.20	0.43±0.03	5.1±0.46	0.28±0.01	15.8±1.36	7.3±0.16	5.4±0.06	7.0±0.4
	T2	67.2±2.1	3.4±0.06	3.3±0.05	0.5±0.01	8.6±0.12	0.31±0.01	31.6±4.34	8.3±0.05	6.8±0.13	9.6±0.4
V6	T1	67.4±1.7	2.6±0.17	2.5±0.23	0.6±0.02	4.1±0.2	0.31±0.03	14.6±3.43	8.1±0.04	6.2±0.14	7.3±0.8
	T2	78.3±3.2	3.6±0.26	2.7±0.22	0.7±0.027	4.5±0.31	0.4±0.023	27.9±2.66	10.0±0.1	7.1±0.15	8.2±0.2
V7	T1	38.0±2.2	2.4±0.03	3.6±0.16	0.55±0.02	4.3±0.43	0.29±0.03	15.7±2.07	7.2±0.12	5.6±0.07	5.9±0.2
	T2	41.6±2.6	2.3±0.08	2.6±0.22	0.57±0.01	3.8±0.36	0.23±0.02	10.9±0.84	6.7±0.35	5.2±0.01	5.5±0.2
V8	T1	48.0±1.5	2.2±0.04	2.2±0.24	0.47±0.04	4.2±0.53	0.18±0.01	8.8±0.87	6.9±0.13	5.5±0.10	4.9±0.5
	T2	67.5±3.5	2.9±0.07	2.4±0.14	0.61±0.04	6.8±0.26	0.21±0.22	15.1±1.12	7.8±0.05	6.2±0.17	7.2±0.5
V9	T1	52.2±1.6	2.4±0.09	2.2±0.12	0.55±0.03	4.4±0.23	0.23±0.04	8.05±1.23	8±0.12	6.5±0.06	4.7±0.8
	T2	60.5±1.6	2.9±0.07	2.5±0.22	0.65±0.07	8.7±0.54	0.3±0.01	14.1±1.07	9.2±0.21	7.7±0.16	7.0±0.5
V10	T1	42.7±1.6	2.4±0.11	1.7±0.05	0.47±0.01	3.3±0.32	0.24±0.04	11.4±0.88	6.7±0.06	5.5±0.08	4.8±0.4
	T2	53.3±4.2	3.0±0.26	2.3±0.20	0.5±0.03	5.7±0.34	0.28±0.02	24.6±5.29	7.6±0.07	6.1±0.18	8.4±0.5
Tm											
T1		57.9±19.8b	2.52±0.4b	3.11±1.2b	0.54±0.08b	5.2±1.7b	0.25±0.05b	15.0±5.9b	7.70±0.8b	6.06±0.7b	6.75±2.0b
T2		69.5±27.6a	3.03±0.5a	3.25±1.2a	0.65±0.15a	7.9±2.8a	0.29±0.06a	23.8±11.3a	8.68±1.5a	6.73±1.0a	8.82±2.7a

The results are expressed as means ± standard error of the mean. Means with different letters in a vertical column indicate a significant at the 5% probability level based on Tukey's test. Treatments (T1: Adult coconut plantation, T2: Juvenile coconut plantation); varieties (V1: Damask rose, V2: Rose Sherbet, V3: Arunima, V4: Pusa Arun, V5: Pusa Muskan, V6: Ashwini, V7: Shola, V8: Pusa Manhar, V9: Soma, V10: Abhisarika) each variety in a season i.e., 14 (Abhisarika) to 43 (Arunima) flower stocks/ plant. Significant differences were also noticed for average number of flowers harvested under two types of coconut plantations. Increased flower bud number and flower diameter in plants grown under higher light intensities have been recorded by Zieslin and Mor (14) in roses. Thakur *et al* (12) also stated decrease in flower yield of *R. damascena* monocrop with increasing shade levels as compared to sunny conditions. The reproductive growth of the plants depends upon availability of assimilates and its increased transport to the young shoots (Mass and Bakx, 7). The availability of assimilates can be increased either by higher rates of photosynthesis or by shifting in partitioning of assimilates (Mor *et al*., 8; Mortensen *et al*., 9). Availability of light positively influences the assimilate partitioning in roses (Mor *et al*., 8). The phenomenon of increase in the flower yield under more intensity is probably associated with increased irradiance for photosynthesis or assimilation by plants. Comparable results were also reported by Kamoutsis *et al*. (5) in *Gardenia* spp.

Chlorophyll is considered as a direct indicator for photosynthetic potential in plants, helps knowing the plant nutrient status, stress, senescence, plant health etc. Slight differences were noticed for chlorophyll and chlorophyll fluorescence values among the varieties between the plantations, but these differences were not significant. Significant differences were also not observed for total carotenoids, phenols, and sugars between varieties as well as plantations.

The pest and disease incidence are concerned; during wet month's incidence of castor semi looper, leaf eating caterpillar was observed in roses whereas in dry months attack of aphids and mites were seen. Dieback and black spot are major diseases observed in this area. Percent pest incidence observed in different varieties ranged from 19.97% (Pusa Arun) to 52.97 % (Pusa Manhar). Similarly, a disease incidence varied from 7.3% (Damask rose) to 25.17% (Pusa Muskan) in tested varieties. But significant differences were not seen for the pest and disease incidence between the plantation groups. Among all varieties Damask rose was found to be comparatively tolerant to diseases dieback and black spot followed by Ashwini, Soma and Pusa Arun, while high disease incidence was noticed in varieties Pusa Muskan and Pusa Manhar. The yield data of coconut has showed 22% increase in nut yield (Table 2) after initiation of intercrop, which explains the positive influence of intercrop on main crop. The additional nutrition and irrigation might have benefited the main crop to increase its productivity.

Table 2. Data recorded on average nut yield of the palms (mature palms) in the intercropped coconut field, before (2016-17) and after (2018-20) intercropping with roses

Palm No.	Nut yield/palm/Year (Before intercropping)		Nut yield/palm/Year (With intercropping)	
	2016-17	2017-18	2018-19	2019-20
1	117	91	141	109
2	106	109	127	131
3	109	163	131	196
4	119	158	143	189
5	112	112	134	135
6	132	111	159	134
7	112	128	135	154
8	98	117	117	141
9	97	104	116	125
10	104	108	125	130
11	124	121	149	145
12	109	113	131	136
13	108	98	130	118
14	127	94	153	113
15	167	98	200	118
16	136	82	164	99
17	134	95	161	114
18	123	81	148	98
19	142	111	171	134
20	161	123	193	148
21	117	177	140	212
22	104	98	126	118
Mean	120.81	113.27	145.18	136.22
Avg. nut yield	117.04		140.7	

Capital productivity analysis is the most important tool for evaluating the financial feasibility of any project. The ex-ante concept of cost-benefit analysis is adopted to evaluate the current project (Coconut + Rose intercropping system). The study was confined to the direct costs and benefits, and the social cost-benefit aspects are not included. The benefit-cost ratio (BCR) of rose as intercropping with coconut was found to be 1.38 with an internal rate of return (IRR) of 22 per cent. Furthermore, the BCR and IRR of the system were found to be higher than that of the coconut monocrop (1.24 and 14 per cent, respectively). General theory and empirical studies on project feasibility analysis on cropping systems indicate that a system with a BCR value above 1 is always feasible. In the present study, the IRR of the system is well above that of any other prevailing market rate of return. Thus, we may conclude that the Coconut + Rose cropping system could turn out to be a highly profitable venture.

Comparatively superior plant growth and flowering of roses were observed under Juvenile coconut plantation over aged coconut plantation. The performance differences discerned among rose cultivars highlights the importance of genotype selection for intercropping under coconut plantation. Cultivation of roses in tropical humid climate necessitates much care since crop is more prone to pests and diseases.

AUTHORS' CONTRIBUTION

Conceptualization of research (AV, KPS, N, SN); Designing of the experiments (AV, SP, RB); Contribution of experimental materials (AV, N, SP, RB); Execution of field/lab experiments and data collection (AV, SV); Analysis of data and interpretation (AV, VK); Preparation of the manuscript (AV).

DECLARATION

The authors do not have any conflict of interest.

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