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Can medicinal plants provide sustainable economic security to dry land farmers?

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Abstract
This study was conducted on intercropping of medicinal crops *viz*., ashwagandha, garden rue, roselle and holy basil with pigeon pea and nipped castor in *alfisols* of eastern dry zone of Karnataka in *kharif* 2012. Intercropping of ashwagandha significantly reduced the growth and yield of field crops. The pigeon pea /castor + garden rue system performed better than sole crops of field crops. The yield of medicinal crops reduced due to intercropping. Sole crop of garden rue recorded significantly higher dry herb yield (1.43 t ha^{-1}). Sole crop of roselle recorded highest fresh calyx yield (3.37 t ha^{-1}) followed by pigeon pea intercropping (2.94 t ha^{-1}) and castor intercropping (2.47 t ha^{-1}). Pigeon pea + garden rue recorded maximum LER, ATER and net returns of 1.98, 1.82 and ` 29533.00 ha^{-1}, respectively with a B: C ratio of 0.89.

Keywords: roselle, holy basil, garden rue, ashwagandha, LER, ATE

Introduction
The dry land farming is practiced on about 101 million hactares of the total 143 million hactares of arable land in India. Unfortunately the research on dry land farming has not been given due attention. It is rightly said that 'the second green revolution can be made possible only by dry land farmers' as the additional food has to come from the dry land farming only, which is known for erratic rainfall and crop failure due to droughts during critical stages. To keep the dry land farmers on field it is very essential to provide them financial security from their farm, which can be achieved by adoption of proper and scientifically designed crop diversification. Medicinal crops can be employed for crop diversification as they constitute 30 per cent of the allopathic drugs and a major part of many traditional medicinal systems worldwide. The annual demand of botanical raw drugs in the country as well as overseas is on the increasing trend with an estimated annual turn-over of the herbal industry in the country at ` 8800 crores (Ved and Goraya, 2008) [10]. But many of the medicinal crops are associated with long gestation period, large fluctuation in production potential and discouraging government policies as impeding factors. Further, intercropping medicinal crops with crop components is an attractive option, as that would increase land use efficiency and besides improving the economic status of the farmers (Kurian *et al*., 2003) [5]. Inclusion of medicinal crops along with other routine crops or crops of the farmer's choice or crops in demand or commercial/cash crops, crops for subsistence of the farmer of the region will not disturb his normal practices and besides increasing his income. As a step forward in this direction, an investigation on intercropping of medicinal crops in *alfisols* of dry land conditions in Eastern Dry zone of Karnataka was carried out to integrate the medicinal crops (garden rue, ashwagandha, roselle and holy basil) as intercrops with field crops, pigeon pea and castor.

Material and methods
The field experiment was carried out at the Post Graduate Center, University of Horticultural Sciences (Bagalkot), GKVK, Bengaluru, during *kharif* 2012. The experimental site is situated in Eastern Dry Zone (Zone – 5) of Karnataka, which is 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 soil of the experimental site was red sandy loam with acidic pH (5.11), medium EC (0.086 dSm^{-1}),

low organic carbon and available P_2O_5 (0.45% and 29.37 kg ha^{-1}, respectively), and medium in available N and K_2O (297.92 and 163kg ha^{-1}, respectively) and grouped under *Alfisols*.

An abnormal weather prevailed during the cropping season resulting in low rainfall and frequent long dry spells during critical stages of crop growth *viz*., germination stage, vegetative and reproductive stages of crops. The highest monthly rainfall was received in August (2012) (100.1mm) and the lowest was in June (26.6 mm) while the total rain fall during the cropping period was 458.1 mm. The rainfall distribution was erratic with maximum rainy days (9) in July and minimum in September (2). The monthly mean relative humidity ranged from 88 per cent in December to 93.0 per cent in July. While, the evening monthly mean relative humidity in the morning ranged from 51.0 per cent in September to 53.0 per cent in August, October and November (Table 1). Hence, two irrigations of about 10 mm depth were given to ensure good germination.

The experiment comprised of 4 medicinal plants *viz*., garden rue (*Ruta graveolens L.*), ashwagandha (*Withania somnifera* Dunal. cv. Poshita), roselle (*Hibiscus sabdariffa* L. var. sabdariffa) and purple type of holy basil (*Ocimum sanctum* L.) and two field crops *viz*., pigeon pea (*Cajanus cajan* (L.) Millsp. cv. BRG-1) and nipped castor (*Ricinus communis* cv. DCH-9) laid out in Randomized Complete Block Design (RCBD) with three replications with a gross plot size of 28.8 sq. m.

The treatments consisted of six sole crops, four intercropping combinations of medicinal crops with each of red gram and castor. Three rows of ashwagandha, two rows of garden rue and holy basil and one row of roselle were grown as intercrops in between two rows of pigeon pea and castor which were spaced 120cm apart. The seed rate for sole crop of garden rue, ashwagandha, roselle and holy basil was 2-2.5, 5.00, 2-3 and 0.2-0.3 kg ha^{-1}. While, it was 12 kg ha^{-1} for both red gram and castor. Whereas 40:40:40, 0:0:0, 90: 60:40, 120:105:105, 25:50:25 + Zinc-15 + Sulphur-20 and 38:38:25kgs of N, P_2O_5 and K_2O were applied to garden rue, ashwagandha, roselle, holy basil, pigeon pea and castor respectively.

The land was ploughed twice, clods were crushed and brought to fine tilth by passing harrow. Irrespective of crops, farm yard manure was applied to each plot at the rate of 10 tons ha^{-1} a month before final levelling and mixed thoroughly. Fifty per cent of nitrogen and entire dose of P and K were applied as basal dose at the time of sowing. The remaining fifty per cent of nitrogen was given as top dressing during earthing up at thirty day after sowing. Bold and healthy seeds of pigeon pea, castor, ashwagandha and roselle were soaked in water over night. Pigeon pea seeds were treated with *Rizobium* and *Trichoderma harzianum*, while, castor, ashwagandha and roselle seeds were treated with Captan @ 2g per kg. Pigeon pea, castor and roselle seeds were dibbled at 0.5 cm depth and the seeds of ashwagandha sown in shallow furrows and the rows were covered with soil in the second week of June. The garden rue and holy basil seedlings were raised in nursery for a month and transplanted to the experimental plots during second week of July. The gap filling was done after eight days of sowing/transplanting and the plots were kept weed free throughout the experimentation.

Castor was nipped at the height of first spike initiation and initiated spike was removed and a vertical branch was allowed to grow from the node below the first spike. Finally four spikes were maintained per plant. The inflorescence was nipped off in holy basil for initial two months of planting to ensure maximum branching and more vegetative growth. Observations were recorded from five randomly tagged plants in each plot. The growth parameters like plant height (cm), plant spread (cm), number of branches per plant, number of leaves per plant, leaf area at harvest (sq. cm) and dry weight of different plant components (g $plant^{-1}$) and different yield parameters were recorded according to the crop. The major chemical constituents of medicinal plants such as anthocyanin in roselle calyces and eugenol in essential oil of holy basil were determined.

Land equivalent ratio (Willey, 1979) [11] and area time equivalent ratio (Hiebsch, 1980) [4] were calculated. The economic analysis was done by considering the market price prevailed during 2012-13.

Table 1: Monthly meteorological data for the year 2012 recorded at the meteorological observatory of AICRP on Dryland Agriculture, UAS, GKVK, Bengaluru.

Standard week	Monthly Mean temperature (°C)		Total rainfall (mm)	Total Number of rainy days	Mean relative humidity (%)		Mean pan evaporation (mm)
	Maximum	Minimum			Morning	Evening	
May	33.0	21.1	84.4	3	88.0	49.0	5.8
June	30.9	20.3	26.6	3	87.0	44.0	6.2
July	28.7	19.6	97.2	9	93.0	52.0	4.5
August	28.3	19.3	100.1	6	93.0	53.0	3.5
September	29.2	19.4	29.2	2	92.0	51.0	4.4
October	28.3	18.7	71.2	4	90.0	53.0	4.6
November	27.2	16.0	38.2	4	88.0	53.0	4.4
December	27.4	15.7	11.2	1	88.0	52.0	4.7

Result and Discussion

Effect of intercropping of medicinal plants on growth and yield of pigeon pea

In the current study the crop experienced severe moisture stress, affecting the plant growth to a greater extent. Only leaf area varied significantly due to different intercropping systems (table 2). The highest values were recorded in pigeon pea + garden rue (1845 sq.cm) followed by sole crop of pigeon pea (1538 sq.cm,) and least was recorded by pigeon pea + ashwagandha (1267 sq.cm) intercropping system.

Due to the severe reduction in rainfall and lack of earthing up operation pigeon pea + ashwagandha intercropping system recorded lowest values for growth parameters. Pigeon pea + garden rue intercropping was found to be advantageous, as it recorded significantly higher number of pods (62), highest seed yield (40.60 g $plant^{-1}$ and 8.28 q ha^{-1}) which also recorded higher values for growth parameters due to conservation of soil moisture as a result of crop cover which reduced evaporation. Patel *et al*. (2013) in a similar study, reported significant influence of black moong intercrop on *rabi* pigeon pea. Since garden rue and pigeon pea explore different soil layers for their nutrient and water requirement, there will be very less or no competition for resources, hence, better growth was observed than other cropping system or sole pigeon pea.

Table 2*:* Effect of intercropping systems on growth and yield parameters of pigeon pea

Treatments	Plant height (cm) At harvest	Plant spread (cm) At harvest	Number of branches per plant At harvest	Leaf area (sq. cm plant^{-1})	Number of pods plant^{-1}	100 seed weight (g)	Seed yield (q ha^{-1})
T $_{5}$- Sole Pigeon pea	98.7	46.0	8.3	1538	53	20.67	7.16
T $_{7}$- Pigeon pea + Garden rue	87.7	43.1	5.7	1845	62	20.40	8.28
T $_{8}$- Pigeon pea + Ashwagandha	76.3	31.3	6.2	1267	38	20.13	4.80
T $_{9}$- Pigeon pea + Roselle	79.6	44.1	5.7	1449	43	20.27	6.73
T $_{10}$- Pigeon pea + Holy basil	82.0	35.5	6.1	1477	42	20.53	5.61
S.Em±	8.1	4.8	1.1	94	4	0.42	0.23
C.D. at 5%	NS	NS	NS	280*	12*	NS	0.76*

*:- Significant, NS:- Non significant

Effect of intercropping of medicinal plants on growth and yield of castor

There was no significant effect of intercropping practices on growth parameters in castor at different stages. Leaf area was significantly high in castor + garden rue (1558 sq.cm g plant^{-1}) intercropping system (table 3) and also performed better than sole crop of castor and resulted in increased yield (6.87 q ha^{-1}) over sole crop of castor (6.46 q ha^{-1}). From a similar study, Agarwal and Porwal (2006) have reported improved growth and yield of castor when planted in paired row and inter cropped with green gram.

Table 3: Effect of intercropping systems on growth and yield parameters of castor.

Treatments	Plant height (cm) At harvest	Plant spread (cm) At harvest	Number of leaves per plant At harvest	Leaf area (sq. cm plant^{-1})	Number of spikes plant^{-1}	Number of capsules spike^{-1}	100 seed weight (g plant^{-1})	Seed yield (q ha^{-1})
T $_{5}$- Sole castor	60.5	54.4	7	1372	2	18	19.73	6.46
T $_{7}$- Castor + Garden rue	63.1	55.8	8	1558	2	18	19.10	6.87
T $_{8}$- Castor + Ashwagandha	54.6	41.3	7	1061	2	16	19.27	4.67
T $_{9}$- Castor + Roselle	57.9	51.1	7	1186	2	17	19.90	4.73
T $_{10}$- Castor + Holy basil	59.8	52.0	7	1250	2	18	20.00	4.73
S.Em±	6.7	7.5	0.4	86	0.17	1.6	0.27	0.47
C.D. at 5%	NS	NS	NS	282*	NS	NS	NS	1.53*

*:- Significant, NS:- Non significant

Effect of intercropping systems on growth, yield and quality of garden rue

There was no significant difference with respect growth of garden rue at all the stages in different intercropping system (table 4). Castor + garden rue intercropping system recorded significantly high leaf area (1377 sq. cm plant^{-1}). In contrast to this, sole crop of garden rue recorded significantly higher fresh and dry herb yield (4.99 and 1.43 t ha^{-1}, respectively). In a related study, Basavaraju (2010) [3] recorded reduction in the green and dry herb yield of garden rue with intercropping in coconut garden due to reduction in population and shade effect.

The rutin content and rutin yield in sole crop were higher (2.2 % and 31.72 kg ha^{-1}, respectively), which may be due to application of recommended quantities of nutrients to garden rue and also due to higher plant population (table 4). Among the intercropping systems, pigeon pea + garden rue recorded more rutin content and yield (1.69% and 19.90 kg ha^{-1}, respectively) than that of castor + garden rue (1.47% and 19.03 kg ha^{-1}, respectively).

Table 4: Effect of intercropping systems on growth, yield and quality parameters of garden rue

Treatments	Plant height (cm) at harvest	Plant spread (cm) at harvest	Number of branches plant^{-1} at harvest	Leaf area (sq.cm plant^{-1})	Fresh herb yield (t ha^{-1})	Dry herb yield (t ha^{-1})	Rutin content (%)	Rutin yield (kg ha^{-1})
T $_{1}$- Sole Garden rue	44.7	27.6	7.3	953	4.99	1.43	2.22	31.72
T $_{7}$- Pigeon pea + Garden rue	44.7	30.3	8.00	1011	4.10	1.18	1.69	19.90
T $_{11}$- Castor + Garden rue	45.1	29.8	8.3	1377	4.44	1.29	1.47	19.03
S.Em±	1.3	0.8	0.7	34	0.07	0.03	-	0.39
C.D. at 5%	NS	NS	NS	135*	0.28*	0.11*	-	1.53*

*:- Significant, NS:- Non significant

Effect of intercropping on growth and yield of Ashwagandha

Even though ashwagandha is a hardy crop known for drought tolerance (Arul Navamani Vijaya Bharathi, 2002), the crop stand was very poor, which might be due to lack of sufficient moisture during germination, a very common problem in *alfisols* particularly during the low and erratic rainfall pattern that prevailed during experimentation. This indicates that the ashwagandha may not be a suitable crop for commercial cultivation in *alfisols* of eastern dry zone of Karnataka, particularly under rainfed conditions.

Effect of intercropping systems on growth yield and quality of roselle

The effect of intercropping was not significant on growth and yield of roselle as there was less shade of pigeon pea and castor on roselle. However, the calyces yield varied significantly due to intercropping. Since the sole cropping of roselle accommodated more number of plants, it recorded highest yield (3.37 ton fresh and 0.40 ton dry yield ha^{-1}) followed by pigeon pea intercropping (2.94 ton fresh and 0.35 ton dry yield ha^{-1}) and castor intercropping (2.47 ton fresh and 0.30 ton dry yield ha^{-1}) (table 5). Sole crop of roselle recorded highest anthocynin yield (1.42 kg ha^{-1}), while lowest was in castor + roselle (1.00 kg ha^{-1}) due to higher calyces yield in sole crop as a result of higher population. Basavaraju (2010) [3] also reported reduction in calyces and seed yield of roselle as a result of reduced number of flowers per plant.

Table 5: Effect of intercropping systems on growth, yield and quality parameters of roselle

Treatments	Plant height (cm) at harvest	Plant spread (cm) at harvest	Number of branches plant^{-1} at harvest	Leaf area (sq.cm plant^{-1})	Number of flowers plant^{-1}	Fresh calyces yield (t ha^{-1})	Dry calyces yield (t ha^{-1})	Seed yield (q ha^{-1})	Anthocyanin yield (kg ha^{-1})
T_1- Sole roselle	88.7	69.5	9.2	2142	47	3.37	0.40	6.45	1.42
T_7- Pigeon pea + roselle	97.1	76.7	8.9	2146	56	2.94	0.35	3.59	1.17
T_{11}- Castor + roselle	88.6	73.3	8.8	2329	49	2.47	0.30	2.80	1.00
S.Em±	3.0	5.2	0.6	138	5	0.14	0.02	0.70	0.07
C.D. at 5%	NS	NS	NS	NS	NS	0.56*	0.07*	2.75*	0.28*

*:- Significant, NS:- Non significant

Effect of intercropping systems on growth, yield and quality of holy basil

All the growth parameters were unaffected due to intercropping systems of the present experiment (table 6). Holy basil intercropped with castor (3.92 ton ha^{-1}) out yielded holy basil intercropped with pigeon pea (2.88 ton ha^{-1}) which differed significantly but it was *at par* with sole crop (4.52 ton ha^{-1}) as sole crop accommodated more number of plants per unit area. The oil yield and eugenol yields were highest in sole crop of holy basil (11.73 and 8.71 kg ha^{-1}, respectively) due to higher plant population in sole cropping system. Mohsin and Singh (2007) [6] recorded higher herbage and oil yields of Japanese mint (*Mentha arvensis*) in pure stands than as intercrop with poplar and eucalyptus.

Assessment of yield advantage in intercropping system

Land equivalent ratio (LER) Area time equivalent ratio (ATER)

Higher LER and ATER was recorded in pigeon pea + garden rue (1.98 and 1.82) and castor + garden rue (1.97 and 1.81) (table 7). Sahoo *et al.* (2006) [8] also reported higher LER of sunflower + groundnut than that of sunflower and black gram due to higher yield of sunflower in this system. ATER was >1, indicating better efficiency of intercropping systems over sole cropping. This result are in line with those of Srilatha *et al.* (2001) [9], who recorded efficient ATER of 1.53 from castor + ground nut, as these crops belong to different families.

Economics of intercropping systems

The highest gross and net returns were obtained from pigeon pea + garden rue (62620.00 and 29533.00 ha^{-1} respectively) among pigeon pea based intercropping system and castor + garden rue (56295.00 and 24200.00 ha^{-1}, respectively) among the castor based intercropping system (table 7). This is due to increased yield of pigeon pea and castor due to intercropping of garden rue with them with an additional yield of garden rue. As the pigeon pea + roselle recorded second highest net returns (28587 ha^{-1}) and lesser cost of cultivation (21308.00 ha^{-1}) than that of pigeon pea + garden rue (33087.00 ha^{-1}) it recorded higher benefit: cost ratio (1.34). While, benefit cost ratio was less in case of pigeon pea + holy basil (0.71) as the price of holy basil was less (5 kg^{-1}), but, better than the sole crop of pigeon pea (0.64). A similar trend of benefit: cost ratio was noticed in respect of castor + holy basil (0.76), castor + roselle (0.75) and castor + garden rue (0.75) as against sole crop of castor (0.37). Similarly, Patel *et al*. (2013) reported improved benefit: cost ratio from pigeon pea + black moong as a result of yield increase in pigeon pea over sole crop. The same trend was recorded in pigeon pea + garden rue, wherein the yield was increased in pigeon pea due to intercropping.

Conclusion

The interspaces available in case of pigeon pea and castor can be successfully utilized for cultivation of medicinal crops under dry land conditions in *alfisols* of Eastern dry zone of Karnataka as the intercropping of medicinal crop is proved to be economical and security against dry spells,. Garden rue can be grown as an intercrop with pigeon pea and castor whenever the poor rains are expected and the main crops are sown in late *kharif* provided the garden rue plants are raised in poly bags. Roselle can also be a better option for delayed sowing of pigeon pea and castor.

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