



## Performance of medicinal crops in mango (*Mangifera indica*) based intercropping system under dryland conditions of Jammu subtropics

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### ABSTRACT

Mango (*Mangifera indica* L.) based agroforestry system offers spatial advantage for intercropping in Indian subtropics. Mango is planted at wide spacing to accommodate the large crowns needed to support the fruit yield. Wider spacing of the trees provides the vacant space to the orchardist to grow suitable and synergistic crop (vegetables/ medicinal plants) to supplement his income. The present investigation was done to screen out the best intercrop out of the four crops, viz. ginger, turmeric, kalmegh and stevia that can be grown in old mango orchards. The experiment was laid out at Experimental Farm of Advance Centre for Horticulture Research (ACHR), Sher-e-Kashmir University of Agricultural Sciences and Technology, Udheywala, Jammu, which is located at an altitude of 327m above mean sea level, between 32°73' N latitude and 74°87' E longitude. Mango orchard selected for the study had a very dense canopy and thus the interception of light was only 30-40 percent than that in the open. The results revealed that shade had profound influence on the survival, growth and yield of ginger, turmeric, stevia and kalmegh. The higher values for plant height, number of leaves, were recorded in ginger and turmeric under shade compared to stevia and kalmegh. Stevia had a very poor survival percentage (11.99%) under mango as compared to open. Likewise ginger had a poor survival percentage (13.22%) in the open compared to that under the mango canopy. Thus, it was concluded that under the subtropical conditions of Jammu region, ginger, turmeric and kalmegh can be grown successfully as intercrops under partial shade of mango trees, however, stevia cannot be integrated. The most remunerative crop among the four, in terms of yield was turmeric followed by ginger and kalmegh.

**Key words:** Agroforestry, Ginger, Growth, Kalmegh, Mango, Stevia, Turmeric, Yield

The traditional harmonious farming system the 'agroforestry' practiced by farmers of India is self sufficient to supply food, fodder, fuel and small timber for himself and his livestock. It offers ample scope for efficient utilization of land, water, other natural and human resources than prevalent system of mono cropping. The combination of components, tree and agricultural crops, depending on their spatial and temporal sequence and the climatic and edaphic factors available could be complementary or antagonistic. It is generally envisaged that the overall productivity of an agroforestry land use is generally greater than that of an annual system. The high density multispecies systems ensure farm income and provide livelihood security to the farmers. Agroforestry gives more income to the farmer per unit area of land than pure agriculture or forestry. Among the agroforestry systems prevalent in India, agri-horticulture is a self sustainable which promises efficient resource utilization

and ensures higher economic returns. The system also helps in engaging the labour throughout the year. In the *Kandi* belt of Jammu region of J&K, mango (*Mangifera indica* L.) is a popular fruit and large areas are covered under the mango orchards. People have 30-40 year old orchards and the trees have developed large crowns leaving scanty open space beneath for growing crops.

The inter row space remains thus unutilized and can be optimally managed by growing shade loving crops. In this endeavour, present experiment was undertaken in the university farm at Udheywala to find out the best possible combination of intercrops that can be recommended to the farmers. Four important medicinal crops, viz. ginger (*Gingiber officinalis*), turmeric (*Curcuma longa*), stevia (*Stevia rebaudiana*) and kalmegh (*Andrographis paniculata*) were grown under the canopy of mango trees. The performance of these crops was evaluated under the partial shade of mango trees.

### MATERIALS AND METHODS

The experiment was conducted at the experimental farm, Udheywala, SKUAST-Jammu located at latitude of 32.73° N and longitude of 74.87°E and elevation of 327m from the mean sea level (MSL). The climate of the area

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was sub-tropical with an average annual precipitation of 1200 mm, greater part of which was intercepted during July to October (70 per cent). The mean annual maximum and minimum temperature were 29.6°C and 16.7°C, respectively. Summer months were hot with temperature and humidity ranging from 23.5°C to 35.5°C and 53.0 per cent to 73.50 per cent, respectively. The winter months experienced mild to severe cold conditions with average temperature ranging from 6.5°C to 21.7°C. The study consisted of two structural and functional components, viz. mango fruit tree as woody perennial and four medicinal crops, viz. ginger, turmeric, stevia and kalmegh as intercrops. In addition, the effect of three spacing of intercrops {20×30cm<sup>2</sup> (S<sub>1</sub>), 30×30cm<sup>2</sup> (S<sub>2</sub>) and 30×40cm<sup>2</sup> (S<sub>3</sub>)} on their growth and yield was studied with and without mango. Thus, two experiments with same treatment combinations were laid out separately (i) under mango and (ii) in open without mango.

Four intercrops were grown in the inter-row space of

mango trees in 29 years old orchard of mango cv. *Dashehari* planted at 9 m × 9 m. Ginger, turmeric, stevia and kalmegh grown in tree less plots served as control. The measurable growth attributes like survival percentage, plant height, number of leaves, herbage yield for stevia and kalmegh and rhizome yield in case of ginger and turmeric was recorded.

## RESULTS AND DISCUSSION

Mango orchard selected for the study had a close canopy and the interception of light was only 30-40 per cent. The shade had profound influence on the survival and growth and yield of ginger, turmeric, stevia and kalmegh in comparison to open field conditions.

It is evident from the pooled data of 2015-16 and 2016-17 that survival percentage of ginger in open (13.22%) was meager compared to its survival (90.93%) under the tree cover (Table 1). Turmeric being a shade loving crop had higher (90.52%) survival under the mango tree

Table 1 Survival percentage of medicinal crops under different cropping systems

Treatment combination	Survival percentage					
	Mango intercropping system			Open system		
	2015	2016	Pooled	2015	2016	Pooled
<i>Crops</i>						
Ginger (G)	90.28 (72.19)	91.59 (73.60)	90.93 (72.85)	13.68 (21.62)	12.75 (20.82)	13.22 (21.22)
Turmeric (T)	90.12 (72.03)	90.93 (72.83)	90.52 (72.42)	88.38 (70.34)	89.96 (72.13)	89.17 (71.17)
Stevia (S)	11.31 (19.27)	12.67 (20.65)	11.99 (19.98)	74.64 (60.28)	75.95 (61.26)	75.29 (60.74)
Kalmegh (K)	90.50 (72.43)	91.58 (73.66)	91.04 (73.01)	84.33 (67.21)	84.40 (67.37)	84.36 (67.28)
±SE(m)	1.27	1.36	1.28	1.26	1.45	1.31
CD <sub>0.05</sub>	3.71	3.99	3.74	3.72	4.24	3.85
<i>Spacing</i>						
20×30cm <sup>2</sup> (S <sub>1</sub> )	69.46 (57.98)	70.25 (58.93)	69.86 (58.44)	58.73 (50.14)	58.95 (50.34)	58.84 (50.23)
30×30cm <sup>2</sup> (S <sub>2</sub> )	70.76 (59.13)	71.98 (60.34)	71.37 (59.72)	67.27 (56.26)	67.70 (56.67)	67.48 (56.46)
30×40cm <sup>2</sup> (S <sub>3</sub> )	71.44 (59.82)	72.84 (61.29)	72.14 (60.53)	69.79 (58.18)	70.65 (59.18)	70.22 (58.62)
±SE(m)	1.09	1.18	1.10	1.09	1.25	1.13
CD <sub>0.05</sub>	NS	NS	NS	3.22	3.67	3.33
<i>Crops × Spacing interaction</i>						
G S <sub>1</sub>	89.66 (71.73)	90.36 (72.91)	90.01 (72.27)	11.71 (19.95)	10.67 (19.00)	11.19 (19.48)
G S <sub>2</sub>	91.16 (73.04)	92.55 (74.42)	91.85 (73.71)	13.88 (21.83)	12.83 (20.92)	13.35 (21.38)
G S <sub>3</sub>	90.01 (71.79)	91.86 (73.47)	90.93 (72.58)	15.46 (23.06)	14.76 (22.54)	15.11 (22.81)
T S <sub>1</sub>	88.74 (70.74)	89.20 (71.10)	88.97 (70.92)	86.42 (68.53)	88.27 (70.35)	87.35 (69.41)
T S <sub>2</sub>	90.19 (72.10)	91.24 (73.06)	90.72 (72.57)	89.16 (71.13)	90.19 (72.15)	89.67 (71.63)
T S <sub>3</sub>	91.42 (73.24)	92.34 (74.33)	91.88 (73.76)	89.57 (71.36)	91.42 (73.89)	90.49 (72.48)
S S <sub>1</sub>	10.48 (18.37)	11.56 (19.55)	11.02 (18.97)	60.07 (50.81)	61.23 (51.50)	60.65 (51.15)
S S <sub>2</sub>	11.48 (19.44)	12.55 (20.58)	12.02 (20.03)	79.31 (63.08)	80.69 (64.20)	80.00 (63.62)
S S <sub>3</sub>	11.98 (20.01)	13.90 (21.82)	12.93 (20.95)	84.54 (66.95)	85.93 (68.09)	85.23 (67.44)
K S <sub>1</sub>	88.97 (71.10)	89.89 (72.16)	89.43 (71.61)	76.70 (61.27)	75.63 (60.51)	76.17 (60.88)
KS <sub>2</sub>	90.19 (71.93)	91.58 (73.29)	90.89 (72.57)	86.72 (69.00)	87.07 (69.42)	86.89 (69.20)
K S <sub>3</sub>	92.35 (74.25)	93.27 (75.53)	92.81 (74.84)	89.57 (71.36)	90.49 (72.18)	90.03 (71.76)
±SE(m)	2.19	2.36	2.21	2.19	2.50	2.27
CD <sub>0.05</sub>	NS	NS	NS	NS	NS	NS

\*Figures in parenthesis are square root transformed values.

canopy compared to that in the open (89.17%). Higher temperature and low humidity levels might have hampered the germination and growth of the ginger rhizomes in open. The results are in conformity with Amin *et al.* (2010) and Garima *et al.* (2016) who reported that ginger was a sciophyte and it performed well under partial shade (50±5%) than the open field. Stevia showed poor growth and yield performance under the mango canopy. The survival rate was meager (11.99%) under the trees compared to under full sunlight (75.29%). The result is in agreement with that of Kumar *et al.* (2012), where they concluded that intensive shade should be avoided for stevia cultivation due to increase in the time taken to reach different phenological stages. The sole crop of kalmegh recorded lesser survival percentage (84.36%) than under mango trees (91.04%). Comparing the effect of spacing reveals that under mango intercropping system survival percentage was not affected significantly, however, under open conditions the effect was profound significant (Table 1). The maximum survival percentage

(70.22%) was recorded under 30×40 cm<sup>2</sup> spacing (S<sub>3</sub>) and it was at par with S<sub>2</sub>, while minimum percent survival (58.84) was recorded under S<sub>1</sub> (20×30 cm<sup>2</sup>). The possible explanation could be that at low density plants grow to maximum mature size without competition as compared to when planted at higher density. At higher density plants grow until canopies are densely packed and all light is used. The result is in confirmation with Deng *et al.* (2012) who suggested that most of the variation in growth, competition, yield and energy use of annual crops can be explained with just two parameters: maximal size at maturity, and intrinsic growth rate.

The interaction effect between crops and spacing was found to be non significant under both the cropping systems.

The data presented in Table 2 shows that the shade had a profound impact on the plant height of ginger and the plants attained an average height of 104.16 cm under the mango trees while it remained stunted (36.40 cm) in open. In turmeric, plant height was significantly higher

Table 2 Effect of different spacing and cropping systems on vegetative parameters of medicinal crops

Treatment combination	Plant height (cm)						Number of leaves plant <sup>-1</sup>					
	Mango intercropping system			Open system			Mango intercropping system			Open system		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
<i>Crops</i>												
Ginger (G)	99.25	109.08	104.16	36.74	36.05	36.40	76.81	85.51	81.16	29.88	13.91	21.90
Turmeric (T)	134.35	143.46	138.90	120.73	127.59	124.16	10.38	11.25	10.81	15.36	16.35	15.85
Stevia (S)	65.57	61.22	63.39	69.01	69.92	69.47	23.32	31.25	27.28	184.18	198.89	191.53
Kalmegh (K)	86.41	94.11	90.26	58.96	70.32	64.64	101.20	107.27	104.24	451.48	463.62	457.55
±SE(m)	2.95	3.95	2.67	3.01	2.98	2.79	4.20	4.05	3.15	9.46	8.36	8.81
CD <sub>0.05</sub>	8.63	11.61	7.85	8.82	8.76	8.18	12.33	11.89	9.25	27.77	24.54	25.87
<i>Spacing</i>												
20×30cm <sup>2</sup> (S <sub>1</sub> )	97.46	104.71	101.09	73.30	77.07	75.19	43.81	50.23	47.01	159.57	162.58	161.08
30×30cm <sup>2</sup> (S <sub>2</sub> )	98.13	99.85	98.99	72.63	83.31	77.97	57.95	62.63	60.29	171.00	173.59	172.30
30×40cm <sup>2</sup> (S <sub>3</sub> )	93.59	101.34	97.46	68.15	67.53	67.84	57.03	63.61	60.31	180.10	183.41	181.75
±SE(m)	2.55	3.42	2.31	2.60	2.59	2.42	3.63	3.51	2.73	8.19	7.25	7.64
CD <sub>0.05</sub>	NS	NS	NS	NS	7.59	7.09	10.68	10.30	8.01	NS	NS	NS
<i>Crops × Spacing Interaction</i>												
G S <sub>1</sub>	101.11	108.71	104.91	43.78	34.91	39.34	63.88	68.61	66.24	30.67	11.52	21.09
G S <sub>2</sub>	106.72	115.24	110.98	31.94	42.16	37.05	91.32	98.79	95.05	26.40	11.28	18.84
G S <sub>3</sub>	89.93	103.28	96.60	34.52	31.09	32.80	75.22	89.14	82.18	32.59	18.95	25.77
T S <sub>1</sub>	133.90	144.93	139.42	120.89	128.53	124.71	8.50	9.04	8.77	14.25	14.73	14.49
T S <sub>2</sub>	134.22	132.61	133.41	136.55	145.37	140.96	11.35	12.06	11.70	16.51	17.32	16.92
T S <sub>3</sub>	134.94	152.83	143.88	104.74	108.88	106.81	11.29	12.67	11.97	15.32	17.00	16.16
S S <sub>1</sub>	61.17	65.46	63.31	63.70	72.64	68.17	17.26	25.76	21.51	167.13	187.70	177.42
S S <sub>2</sub>	64.70	57.48	61.09	70.38	73.04	71.71	23.33	31.22	27.27	184.08	197.55	190.82
S S <sub>3</sub>	70.83	60.71	65.78	72.95	64.09	68.52	29.37	36.76	33.07	201.32	211.43	206.37
K S <sub>1</sub>	93.67	99.75	96.71	64.84	72.21	68.53	85.57	97.50	91.54	426.25	436.38	431.31
KS <sub>2</sub>	86.88	94.06	90.47	51.64	72.66	62.15	105.80	108.46	107.13	457.03	468.21	462.62
K S <sub>3</sub>	78.66	88.53	83.60	60.41	66.08	63.25	112.23	115.86	114.05	471.16	486.26	478.71
±SE(m)	5.09	6.85	4.63	5.21	5.18	4.83	7.27	7.02	5.46	16.39	14.49	15.27
CD <sub>0.05</sub>	NS	NS	NS	15.28	NS	14.18	NS	NS	NS	NS	NS	NS

(138.90 cm) under shade than in open (124.16 cm). The stevia plants grew to a height of 63.39cm under shade and it was almost equivalent to the height attained in the open (69.47 cm). Plant height of kalmegh was high (90.26cm) under trees compared to without trees (64.64 cm).

Comparison of spacing under mango intercropping system reveals that the plant height was not affected significantly under shade, however under open conditions the effect of spacing was found to be significant (Table 2). Maximum plant height (77.97 cm) was recorded at spacing  $S_2$  ( $30 \times 30 \text{ cm}^2$ ) and was at par with  $S_1$  while minimum plant height (67.84 cm) was observed under  $30 \times 40 \text{ cm}^2$  spacing. Interaction between crops and spacing was found to be significant under open conditions. Turmeric plants exhibited maximum height (140.96) under  $30 \times 30 \text{ cm}^2$  spacing ( $TS_2$ ) and were statistically at par with  $TS_1$ . Minimum plant height (32.80 cm) was observed under treatment  $GS_3$ .

The height of the intercrop was significantly affected due to overhead shade of the trees and different spacing of the intercrops. The reason for height elongation in all the crops and in all the treatments except stevia under mango may be attributed to poor light intensity. Low light intensity might have reduced the rate of evaporation of water from the soil thereby increasing the moisture availability to the intercrop. This probably increased the nitrogen supply to plants through water absorption which might have caused more vegetative growth of the intercrop. The similar results were also reported by Solanki *et al.* (2014), Chauhan *et al.* (2013) and Padmapriya and Chezhiyan (2009) for different intercrops under different tree species.

Maximum height increment was found in the treatments with closer spacing. Possible reason for this could be that closer spacing resulted in more competition for interception of light thereby causing increment in the height growth.

Table 3 Effect of different spacing and cropping systems on yield of medicinal crops

Treatment combination	Fresh yield (q ha <sup>-1</sup> )						Dry yield (q ha <sup>-1</sup> )					
	Mango intercropping system			Open system			Mango intercropping system			Open system		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
<i>Crops</i>												
Ginger (G)	55.77	59.91	57.84	5.61	4.89	5.25	8.23	8.82	8.52	0.83	0.72	0.77
Turmeric (T)	91.03	81.82	86.42	175.40	166.01	170.70	13.99	12.51	13.25	26.22	26.49	26.36
Stevia (S)	0.30	0.37	0.33	22.31	23.51	22.91	0.10	0.11	0.10	7.83	7.94	7.88
Kalmegh (K)	41.81	52.71	47.26	108.82	119.73	114.28	17.29	22.10	19.69	44.97	49.50	47.24
±SE(m)	4.14	8.30	4.07	4.82	9.41	5.96	0.68	1.36	0.71	1.22	1.92	1.47
CD <sub>0.05</sub>	12.14	24.50	11.84	14.13	27.76	17.59	1.99	4.03	2.07	3.56	5.66	4.34
<i>Spacing</i>												
20×30cm <sup>2</sup> (S <sub>1</sub> )	59.71	63.19	61.45	90.94	95.71	93.32	12.51	14.06	13.26	22.61	24.09	23.36
30×30cm <sup>2</sup> (S <sub>2</sub> )	45.47	48.61	47.04	68.85	74.26	71.55	9.57	11.17	10.37	18.42	20.82	19.62
30×40cm <sup>2</sup> (S <sub>3</sub> )	36.49	34.31	35.40	74.32	65.62	69.97	7.62	7.48	7.55	18.86	18.57	18.71
±SE(m)	3.59	7.18	3.51	4.17	8.15	5.16	0.59	1.18	0.61	1.05	1.66	1.27
CD <sub>0.05</sub>	10.51	21.21	10.25	12.24	24.04	15.23	1.72	3.49	1.79	3.08	NS	3.75
<i>Crops × Spacing Interaction</i>												
G S <sub>1</sub>	72.57	78.98	75.78	7.89	6.41	7.15	10.85	11.79	11.32	1.15	0.93	1.04
G S <sub>2</sub>	53.86	59.09	56.47	5.81	4.91	5.36	7.99	8.72	8.36	0.84	0.71	0.78
G S <sub>3</sub>	40.87	41.68	41.27	3.15	3.34	3.24	5.84	5.95	5.89	0.48	0.51	0.50
T S <sub>1</sub>	112.49	103.58	108.03	212.74	223.17	217.95	17.04	16.22	16.63	31.81	35.65	33.73
T S <sub>2</sub>	85.72	83.71	84.71	139.18	148.25	143.71	12.85	13.20	13.03	20.83	24.48	22.66
T S <sub>3</sub>	74.87	58.18	66.53	174.27	126.60	150.43	12.07	8.11	10.09	26.02	19.34	22.68
S S <sub>1</sub>	0.37	0.44	0.40	21.18	23.14	22.16	0.12	0.14	0.13	7.25	7.33	7.29
S S <sub>2</sub>	0.30	0.32	0.31	23.74	25.24	24.48	0.10	0.10	0.10	8.36	8.89	8.63
S S <sub>3</sub>	0.24	0.30	0.27	22.01	22.14	22.08	0.08	0.10	0.08	7.88	7.59	7.73
K S <sub>1</sub>	53.43	69.77	61.59	121.94	130.13	126.04	22.01	27.88	24.94	50.25	52.47	51.36
KS <sub>2</sub>	42.02	51.32	46.67	106.67	118.66	112.67	17.36	22.63	19.99	43.64	49.21	46.42
K S <sub>3</sub>	29.97	37.06	33.51	97.86	110.41	104.13	12.50	15.78	14.14	41.04	46.83	43.93
±SE(m)	7.17	14.38	6.97	8.35	16.29	10.33	1.78	2.36	1.21	2.11	3.33	2.54
CD <sub>0.05</sub>	NS	NS	NS	24.48	NS	30.47	3.45	NS	3.58	NS	NS	NS

The similar results were also reported by Bhuiyan *et al.* (2012) for ginger and turmeric crops and by Semwal *et al.* (2016) for kalmegh.

The number of leaves in all the medicinal crops was significantly affected by both the systems (Table 2). In case of ginger maximum leaves (81.16) were recorded under shady conditions. In turmeric the number of leaves were recorded to be more (15.85) in the open and less (10.81) under the mango trees. Similarly, maximum number of leaves in stevia (191.53) and kalmegh (457.55) were recorded under open system as compared to shady situation. The higher number of leaves per plant recorded in ginger and turmeric under shade could be credited to the shade loving nature of these crops. It was in sharp contrast to the growth pattern in stevia and kalmegh which showed the close affinity of these crops to the high intensity of incident rays. A marked increase was seen in the growth parameters at wider spacing of 30 x 30cm<sup>2</sup> and 30 x 40cm<sup>2</sup> in all the crops. It might be due to the decreased competition for the resources as the plant population reduced considerably with increasing plant to plant spacing. The increase in growth parameters in ginger and turmeric is in consonance with the findings of Vikram and Hegde (2014), Girija Devi *et al.* (2011) and Sehgal (2011). The reduction in growth parameters under shade in stevia and kalmegh has also been observed by Hazarika *et al.* (2012) and Sanwal *et al.* (2016) in similar crops.

Effect of spacing was found to be significant only under mango based intercropping system. Maximum leaves (60.31) were observed under 30x40 cm<sup>2</sup> spacing (S<sub>3</sub>) and was statistically at par with S<sub>2</sub>. Interaction between crops and spacing was found to be non significant under both the situations.

A significant reduction in yield was seen under mango canopy compared to in the open (Table 3). In ginger the maximum fresh yield (57.84 q ha<sup>-1</sup>) was recorded under mango compared to in open (5.25 q ha<sup>-1</sup>). There was almost 91 per cent reduction in yield in open condition. The possible reason could be that ginger is a sciophyte and the optimum temperature required for its growth is  $\leq 32^{\circ}\text{C}$  with high relative humidity throughout its growth period except at harvesting time. In turmeric highest yield (170.70 q ha<sup>-1</sup>) was recorded in open conditions compared to yield (86.42 qha<sup>-1</sup>) under shade. There was almost 50 per cent reduction in yield under the tree cover compared to the crop grown in open. Leaf yield in stevia was almost negligible (0.33 q ha<sup>-1</sup>) under canopy of mango trees as compared to (22.91 q ha<sup>-1</sup>) in open. It was due to low number of leaves in shade as discussed above. The reduction in the leaf yield has also been reported by Prakash and Pant (2015), Rathore *et al.* (2014) and Bijalwan (2012) under shade. The results are also in agreement with that of Kumar *et al.* (2012), who reported that intensive shade should be avoided for stevia production as it resulted into enhancement of the time taken to reach different phenological stages. In kalmegh, highest fresh yield (114.28 q ha<sup>-1</sup>) was recorded in sole cropping as compared to 47.26 q ha<sup>-1</sup> under shade. The crop yield was about 59 per cent less under the mango trees. . The reduction

could be due to adverse effect of low light intensity under the mango trees. Reduction in herbage yield has also been reported by Sanwal *et al.* (2016) where kalmegh was grown under the chir pine canopy.

Spacing significantly affected the yield and higher fresh yield was recorded in S<sub>1</sub> and lowest was recorded in S<sub>3</sub> in all the three crops under both the conditions. Interaction between crops and spacing was found to be non significant under shade but in open the interaction was found to be significant. However, maximum yield was found in TS<sub>1</sub> (217.95 q ha<sup>-1</sup>) and minimum (3.24 q ha<sup>-1</sup>) in GS<sub>3</sub>.

From the Table 3 for dry yield, it is clear that the same trend of fresh yield was observed for dry yield too. In ginger maximum dry rhizome yield (0.77 q ha<sup>-1</sup>) was recorded in open compared to 8.52 q ha<sup>-1</sup> under the mango trees. In turmeric highest dry yield (26.36 q ha<sup>-1</sup>) was recorded in open conditions compared to yield (13.25 q ha<sup>-1</sup>) under the canopy. In stevia, highest dry yield (7.88 q ha<sup>-1</sup>) was recorded in the open condition and lowest (0.10 q ha<sup>-1</sup>) under canopy of mango trees. In kalmegh, highest dry herbage yield (47.24 q ha<sup>-1</sup>) was recorded in sole cropping as compared to (19.69 q ha<sup>-1</sup>) beneath the tree cover. As evident from results that ginger performed very poor in open, while stevia under the canopy of trees. The poor performance of ginger in open and of stevia under shade has also been proclaimed by Amin *et al.* (2010), Kunhamu *et al.* (2015), Kumar *et al.* (2012) and Hazarika *et al.* (2012).

Spacing significantly affected the yield and higher dry yield was recorded in S<sub>1</sub> and lowest was recorded in S<sub>3</sub> in three crops under both the conditions. Interaction between crops and spacing was found to be non significant in open but under shade the interaction was found to be significant. Maximum yield was found in KS<sub>1</sub> (24.94 q ha<sup>-1</sup>) and minimum (0.08 q ha<sup>-1</sup>) in SS<sub>3</sub>. The wider spacing performed the best but the yield was higher for the closer spacing of 30 x 20cm<sup>2</sup> in all the crops except stevia under mango and ginger in open. It could be probably due to higher plant population in closer spacing than in the wider spacing. The results are in conformity with Reddy *et al.* (2016), Ghosh and Hore (2011) and Suresh *et al.* (2010).

### Conclusion

The integration of crops with orchard trees result into varied biological interactions, where woody and non-woody components of the system compete with each other for the critical resources. The growth and yield of the intercrops showed that shade was the key factor, limiting the productivity of crops in the system under study. The crop with greater intrinsic ability to undergo quick adjustments always has an added advantage. Stevia cannot be taken as intercrop due to poor survival under mango canopy. Kalmegh, ginger and turmeric performed comparatively better under the shade of mango in terms of growth though biological yield was less in contrast to the yield in open. It implies that these crops can be successfully introduced into mango based system with limited light interception.

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