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Yield and Quality of Off Season Mango under Different Planting Densities

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Abstract

Induction of off-season bearing under different planting densities in mango (Mangifera indica L.) cv.Neelum were conducted at the Horticultural College and Research Institute, Periyakulam. Soil application of paclobutrazol @ 0.75 a.i per tree and pruning immediately after the emergence of new growth were imposed on mango trees planted at four different spacings viz. 5m x 5m, 5m x 4m, 5m x 3m and 5m x 2m. This experiment was laid out in a factorial randomized block design with three replications and twenty-four treatments. The field observations on yield, total Soluble Solids and nut weevil incidence for the main season and off-season crops were recorded. The results of this study revealed that treatment with heading back of 10cm terminal growth after the emergence of new growth (vegetative and floral growth) during December to January with soil application of paclobutrazol @ 0.75 g a.i per tree as soil application during March and April for the trees planted at the widest spacing of 5m x 5m was the best treatment combination for the production of off-season bearing in the mango cv. Neelum. It was interesting to observe that there was no incidence of nut weevil in the off-season crop where as the main season crop registered 23.33 to 56.66 per cent damage. The proportion of yield in the off-season due to this treatment was higher than the main season crop. The total soluble solids content was also higher in the off-season crop than the main season crop.

Keywords: Mango; Mangifera indica; nut weevil incidence; off-season bearing; paclobutrazol; pruning; spacing

Introduction

Mango occupies a pre-eminant place among the fruit crops grown in our country. India is the largest producer and consumer of mangoes in the world and accounts for about 50 per cent of the world production. The area and production under mango in India around 23.15 million hectares and 208.99 million tonnes respectively (Horticulture Statistics Division DAC&FW, 2021). In Tamil Nadu mango is cultivated in an area of about 1,32,697 hectares with a production of 6,36,330 tonnes.

The productivity of mango is very low in Tamil Nadu with 5.35 tonnes per hectare when compared to the average national productivity of 8.71 tonnes and 30.00 tonnes per hectare in India and Israel respectively. The poor productivity is due to the existence of old and senile orchards, irregular bearing. poor population per unit area, non-adoption of improved technologies particularly training, pruning, irrigation management, nutrient management, use of growth regulators and plant protection. Further, the seasonal glut in the market has been a major problem for the farmers in realizing the expected return.

The recent research strategies have been mainly focused on high density planting system concomitant with development of suitable canopy management practices that induce off-season bearing and ensure quality fruits both for domestic and export market. Earlier studies on these aspects have shown encouraging results. The high density planting has been found to be beneficial in increasing the productivity, improving the quality, ensuring better land use efficiency and easy management (Ram and Sirohi, 1988)

The pruning technology has been proved to be a tool to regulate the tree size and shape to achieve the desired compact canopy architecture which in turn facilitates easy management of canopy besides the pests and diseases (Madhava Rao and Shanmugavelu, 1975). The judicious use of growth retardants particularly paclobutrazol has given encouraging results in inducing regular bearing as well as off-season bearing in several varieties (Peiris et al. 2001). Canopy management in mango cv. Alphonso under UHDP maximized the yield and maintained the optimum canopy size without overlapping. Gopu et al. (2014) reported that tipping off encouraged emergence of more flower producing shoots resulting in better yield (19.96 kg/tree). Pandey and Singh (2008) also reported alternate pruning method for sustainable production in mango cv. Amrapali. Flowering and fruiting in mangoes in the top end with Paclobutrazol (Kulharni, 2006).

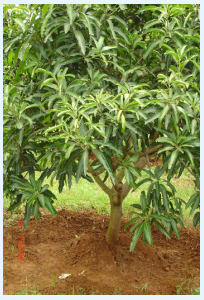
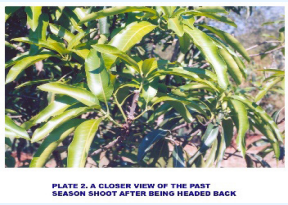
In Tamil Nadu, among the commercial varieties Neelum is a popular one and occupies a sizeable area. Often this late cultivar arrives the local market during June to August, coinciding with the rainy season, consequently fetches poor price for the growers. On the other hand, if this cultivar is made to bear during the off-season i.e. during October – December, the price realization for the farmers will be good. However, no work on this line has been carried out in Tamil Nadu.

Considering the beneficial effects of the above technologies and based on the felt-need of the farming community, the present investigation on yield and quality of off season mango under different planting densities were undertaken to study the combined effect of heading back and paclobutrazol (pp333) on the productivity and quality of mango cv. Neelum during the main and off-season under different planting densities.

Materials and Methods

A field experiment on the induction of off- season bearing under different planting densities in mango (Mangifera indica L.) cv. Neelum was undertaken at the experimental orchard of the Horticultural college and Research Institute, Periyakulam, which is located at 10° N and 77° E. The soil of the experimental field was of sandy loam with medium N, P and K status. The soil pH and EC were 7.75 and 0.34 dsm- [1] respectively.

Induction of off season bearing in Mango (Mangifera indica.L)

Before Pruning	Pruning of terminal shoots (10 cm) immediately after emergence of new growth (floral or vegetative growth)	Immediately after pruning application of Fytolan paste or slurry (or) cowdung paste
		
After pruning emergence of new flushes	Holes at 15cm away from the tree trunk	Holes of 1 to 1½ feet depth (6-8 holes/tree)
 PLATE 2. A CLOSER VIEW OF THE PAST SEASON SHOOT AFTER BEING HEADED BACK		
Paclobutrazol (PP^{333}) @ 1ml/2lit water	Mixing of paclobutrazol	Application of chemicals on the holes
		
Immediately close the holes	90 days after paclobutrazol application (on season/main season)	90 days after paclobutrazol application (off season)
		
Off season mango		
		

The treatments were imposed on nine years old uniform sized trees which were planted at four different spacings (Factor 1) viz., 5m x 5m (S 1), 5m x 4m (S2), 5m x 3 m (S3) and 5m x 2 m (S4). The other treatments comprised of three levels of pruning (Factor 2) viz., control- no pruning (To), pruning of terminal shoots (10cm) immediately after fruit set during August (T1) and pruning terminal shoots (10cm) immediately after the emergence of new growth (floral or vegetative growth) during December - January (T2) and paclobutrazol treatments (Factor 3) viz; control- plain water (P0) and paclobutrazol (pp 333) soil application @ 0.75 g a.i per tree (P1).The paclobutrazol was applied after diluting with three liters of water and drenched along the drip circle in 15 to 20 cm deep holes made with a crowbar and the trees were irrigated immediately. The experiment was conducted in a Factorial Randomized Block Design (FRBD) with three replications. There were totally 24 treatments and the number of trees per treatment was two.

Experimental details

Design: Factorial Randomized Block Design (FRBD)

Number of factors: 3

Number of treatments: 24

Number of replications: 3

Number of trees per treatmental unit: 2

Factor I Spacing

S_1 – 5 m x 5 m (400 trees per ha)

S_2 – 5 m x 4 m (500 trees per ha)

S_3 – 5 m x 3 m (666 trees per ha)

S_4 – 5 m x 2 m (1000 trees per ha)

Factor II Pruning

T_0 – No pruning (Control)

T_1 – Pruning of terminal shoots (10 cm) immediately after fruit harvest during August

T_2 – Pruning of terminal shoots (10 cm) immediately after emergence of new growth (floral or vegetative growth) during December-January.

Factor III Paclobutrazol

P_0–Plain water without paclobutrazol (control)

P_1–Paclobutrazol (PP333) soil application @ 0.75g a.i. per tree.

The paclobutrazol was applied after diluting with three litre of water and was drenched along the drip circles in 6-8 holes made by using a crowbar, then the trees were irrigated immediately.

The field observations were recorded for yield, total soluable solids and nut weevil incidence for the main season and off season crops. The total weight of the fruits per tree was recorded and expressed in kilograms (kg). Five ripe fruits were randomly selected and TSS was recorded using a hand refractrometer and the mean expressed in° brix. The nut weevil incidence was observed in the harvested fruits. Fruit samples (ten fruits) were randomly selected from each treatment and the percent damage was worked out using the following formula.

$$\text{Per cent demage} = \frac{\text{Number of affected fruits}}{\text{Total number of fruits observed}} \times 100$$

The data of the experiment were analysed statistically as per the standard procedure of Panse and Sukhatme (1967).

Results and discussion

The field experiment on induction of off-season bearing in mango under the different planting densities were under taken in the regular bearing cv.Neelum. A comparision of yield (Table1 and 2) among the different planting densities has revealed that the widest spacing (5m x 5m) registered the highest number of fruits 127.44 per tree and main season 109.50 per tree. Meanwhile, yield of 18.11 kg and 14.80 kg per tree in the off-season and the main season respectively (Table 3 and 4). Further as the planting density increased, the yield per tree decreased, the least being recorded with the closest spacing of 5mx2m. This is normally expected under high density planting due to the competition of the trees for nutrients, moisture and light. Such similar reduction in yield under high density planting of mango has been well documented (Majumdar et al 1982, Pandey and Majumdar, 1988; Ram and Sirohi, 1988)

Table 1: Effect of spacing, pruning and paclobutrazol (PP333) on number of fruits per tree during "main" season

	S_1			S_2			S_3			S_4			T/ Mean	P_0/ Mean	P_1/ Mean
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean			
T_0	52.33	113.33	25.67	118.00	71.84	13.67	63.33	38.50	38.50	13.33	40.67	27.00	62.67	26.25	99.08
T_1	38.67	318.33	178.50	54.00	286.00	170.00	35.67	132.33	84.00	30.00	77.67	53.84	121.58	39.58	203.58
T_2	29.00	44.33	36.67	27.67	27.67	27.67	15.00	27.33	21.17	6.33	12.00	9.17	23.67	19.50	27.83
Mean	40.00	178.99	**109.50**	35.78	143.89	**89.84**	38.00	60.05	**52.03**	16.55	43.45	**30.06**		**28.44**	**108.03**

	S	T	P	S x T	T x P	S x P	S x T x P
SE (d)	6.64	5.75	4.69	11.51	8.14	9.39	16.27
CD (5%)	13.37 **	11.58 **	9.46 **	23.16 **	16.38 **	18.91 **	32.76 **

Table 2: Effect of spacing, pruning and paclobutrazol (PP333) on number of fruits per tree during "off" season

	S_1			S_2			S_3			S_4			T/Mean	P_0/ Mean	P_1/ Mean
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean			
T_0	120.0	201.67	160.84	112.0	177.66	144.83	43.33	112.33	77.83	30.33	91.66	60.99	111.13	76.42	145.83
T_1	73.33	64.33	68.83	78.33	44.66	61.50	46.33	32.33	39.33	36.66	24.00	30.33	50.00	58.66	41.33
T_2	42.66	262.66	152.66	50.33	197.66	123.99	27.00	178.66	102.50	26.33	133.33	80.17	114.83	36.58	193.17
Mean	78.66	176.22	**127.44**	80.22	139.99	**110.11**	38.89	107.77	**73.33**	31.11	82.99	**57.05**		**57.22**	**126.75**

	S	T	P	S x T	T x P	S x P	S x T x P
SE (d)	2.42	2.09	1.71	4.19	2.96	3.43	5.93
CD (5%)	4.87 **	4.22 **	3.44 **	8.45 **	5.97 **	6.89 **	11.95 **

Table 3: Effect of spacing, pruning and paclobutrazol (PP333) on yield (kg per tree) during "main" season

	S_1			S_2			S_3			S_4			T/ Mean	P_0/ Mean	P_1/ Mean
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean			
T_0	6.73	18.66	12.69	5.73	17.00	11.18	4.13	11.16	7.65	2.63	9.33	5.98	9.38	4.81	14.04
T_1	10.50	40.00	25.25	12.66	33.00	22.83	8.90	15.72	12.31	8.40	14.00	11.20	17.89	10.12	25.68
T_2	4.73	8.16	6.45	3.75	4.58	4.17	2.73	4.00	3.36	1.80	3.80	2.80	4.20	3.25	5.14
Mean	7.32	22.27	**14.80**	7.38	18.19	**12.79**	5.25	10.29	**7.77**	4.27	9.04	**6.66**		**6.06**	**14.95**

	S	T	P	S x T	T x P	S x P	S x T x P
SE (d)	0.66	0.57	0.46	1.14	0.81	0.93	1.62
CD (5%)	1.33 **	1.15 **	0.94 **	2.30 **	1.63 **	1.88 **	3.26 **

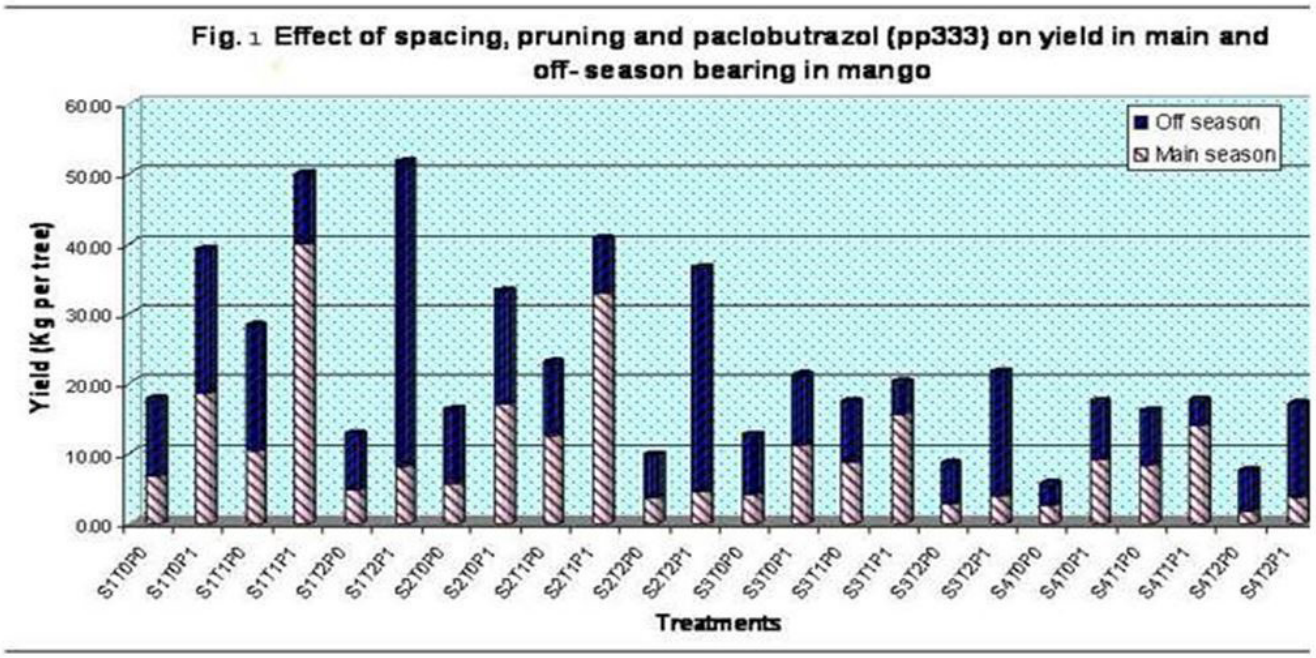
Table 4: Effect of spacing, pruning and paclobutrazol (PP333) on yield (kg per tree) during "off" season

	S_1			S_2			S_3			S_4			T/	P_0/	P_1/
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	Mean	Mean	Mean
T_0	11.00	20.50	15.75	10.50	16.16	13.33	8.50	10.00	9.25	3.03	8.07	5.65	10.97	8.26	13.68
T_1	17.66	10.00	13.83	10.33	7.76	9.04	8.43	4.44	6.44	7.65	3.62	5.63	8.73	11.02	6.45
T_2	8.00	43.50	24.75	6.00	32.00	18.86	5.81	17.66	11.74	5.73	13.30	9.57	16.23	6.39	26.62
Mean	12.22	24.66	**18.11**	8.94	18.64	**13.75**	7.58	10.70	**9.14**	5.47	8.33	**6.90**		**8.55**	**15.58**

	S	T	P	S x T	T x P	S x P	S x T x P
SE (d)	0.69	0.60	0.49	1.20	0.84	0.98	1.69
CD (5%)	1.39 **	1.20 **	0.98 **	2.41 **	1.71 **	1.97 **	3.42 **

It is an established fact that induction of off-season bearing in mango can be achieved through judicious pruning with chemical manipulation. The heading back of terminal shoots and soil application of paclobutrazol were found to be very effective in inducing off-season flowering and bearing without any impact on quality of fruits in mango (Hiller, 1991; Hoda et al. 2001).

As the main objective of this investigation is to induce off-season flowering, thus off-season cropping to realize maximum income, an analysis on the percentage of main season crop and off-season crop was worked out and depicted in Figure l. This clearly shows that among the two types of pruning, pruning of terminal shoots (10 cm) immediately after emergence of new growth (floral or vegetative growth) during December-January was effective in inducing more percentage of off-season flowering in June-July in the following year. On the other hand, a sizeable percentage of off-season flowering shoot during December to January is a prerequisite to induce off-season flowering in June-July in the following year.



On the other hand, a sizeable percentage of off-season cropping was also realized with control as well as in trees receiving the treatment viz., pruning of terminal shoots (10cm) immediately after fruit harvest during August. This may be due to inherent genetic nature of the cv. Neelum which is often reported to be an 'Off season bearer' in many districts of Tamil Nadu. The off-season cropping obtained with pruning of terminal shoots (10 cm) immediately after fruit harvest during August may be also partially ascribed to the varietal nature and also due to the delay in attaining the required maturity of the new shoots produced due to the effect of pruning.

A comparison of yield obtained between paclobutrazol treated and without paclobutrazol indicated that there is not much of difference between main and offseason crops. The role of paclobutrazol has been well established in mango wherein, when it is applied at appropriate vegetative growth phase, it suppresses vegetative growth and induces flowering by suppressing the synthesis of endogeneous gibberellins. Similar results have been reported in other mango cultivars from Australia (Winston, 1989), Indonesia (Voon et al. 1991) and Thailand (Tongumpai et al. 1991). Webster and Quinland (1984) reported that the anti-gibberellin activity of paclobutrazol could induce or intensify flowering by blocking conversion of kaurene to kaurenoic acid, a precursor of gibberellin. As paclobutrazol was applied three to four months after pruning under both type of pruning treatments, it is known to induce off-season flowering in all the cases, however, the highest yield (43.50kg per tree) of off-season crop was realized in trees receiving the treatment of pruning of terminal shoots (10 cm) immediately after emergence of new growth (floral or vegetative growth) during December-January and paclobutrazol (Pp333) soil application during March to April.

When paclobutrazol is applied to the soil, it moves up through the roots into the shoots and, due to its anti-gibberellin properties, blocks the synthesis of flowering inhibitors, thereby allowing the flower-promoting factor(s) to work (Kulharni, 2006). Paclobutrazol applied in September was highly effective in flowering, reducing vegetative growth, increasing fruit set and yield as compared to August and October applications. However, August treatment was relatively superior to the October treatment (Karki and Dhakal,2003).

Any management system should aim at maximizing the productivity without any adverse impact on quality of fruits. This is more true in the present investigation wherein the major objective is to permit better aeration and light penetration within the canopy of the tree. Thus the developing fruit will be exposed to the conducive microclimate to assimilate the required quality components.

The evaluation of different treatments for the quality parameters total soluble solids content (Table 5 and 6) revealed that the quality of fruits was better in the off-season crop than the main season. The highest TSS (24.16° brix) were harvested in the off-season from the trees spaced at 5m x 5m which received the treatment of pruning of terminal shoots (10cm) immediately after the emergence of new growth (floral or vegetative growth) during December -January and paclobutrazol (pp 333) soil application during March- April. This is in conformity with the findings of Singh (1958), Madhavao Rao and Shanmugavelu (1975), Padhiar and Patel (2003).

Table 5: Effect of spacing, pruning and paclobutrazol (pp333) on total soluble solids (^{0} brix) during main season

	S_1			S_2			S_3			S_4			T/	P_0/	P_1/
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	Mean	Mean	Mean
T_0	21.33	22.56	21.94	20.83	22.23	21.53	19.83	21.23	20.53	17.66	19.66	18.66	20.66	19.91	21.42
T_1	21.53	24.16	22.84	21.16	23.16	22.16	20.73	22.66	21.69	19.33	19.33	19.33	21.51	20.69	22.33
T_2	20.00	20	20.00	19.00	19.40	19.20	18.50	18.66	18.58	16.00	18.00	17.00	18.69	18.38	19.02
Mean	20.95	22.24	**21.66**	20.33	21.59	**20.96**	19.71	20.85	**20.28**	17.66	18.99	**18.33**		**19.66**	**20.92**
	S			T		P	S x T			T x P			S x P		S x T x P
SE (d)	0.27			0.24		0.19	0.48			0.34			0.39		0.68
CD (0.05%)	0.56 **			0.48 **		0.39 **	0.97 *			0.68 **			0.79 **		1.37 **

Table 6: Effect of spacing, pruning and paclobutrazol (pp333) on total soluble solids (^{0}Brix) during off season

	S_1			S_2			S_3			S_4			T/	P_0/	P_1/
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	Mean	Mean	Mean
T_0	22.40	22.83	22.61	22.16	22.40	22.28	21.40	22.33	21.87	20.50	21.33	20.91	21.91	21.62	22.22
T_1	22.16	23.83	22.99	21.83	23.36	22.60	21.40	22.70	22.05	20.83	21.40	21.12	22.19	21.56	22.82
T_2	22.83	24.16	23.49	21.80	23.16	22.48	21.30	22.40	21.85	21.00	22.23	21.61	22.35	21.73	22.99
Mean	22.46	23.68	**22.92**	21.93	22.97	**22.45**	21.36	22.48	**21.93**	21.80	21.70	**21.21**		**21.73**	**22.65**
0		S		T		P		S x T		T x P			S x P		S x T x P
SE (d)		0.08		0.07		0.05		0.14		0.10			0.11		0.20
C D (0.05%)		0.16 **		0.14 **		0.11 **		0.28 **		0.20 **			NS		0.40 **

In most of the cases difference between spacing, pruning and paclobutrazol treatments was of trivial nature for the quality attributes. However, they remained superior over control suggesting the beneficial effect of canopy management which involved removal of apical growth, permitting better light interception and enhanced fruit quality. Further, the beneficial effect of optimum spacing and pruning on quality of fruits may be due to better partitioning of assimilates to the sink.

Nut weevil (Sternochetus mangiferae F.) is a serious pest of mango in southern states? It is a major constraint for the export of fresh mango fruits in view of the embargo imposed by USA and Japan on the export of fresh mangoes from our country. Since the cultivar Neelum, experimented in the present study, is highly susceptible to this dreaded pest, the role of canopy management was assessed on the incidence of nut weevil. It was interesting to observe that all the fruits harvested during the off-season were completely devoid of nut weevil. But in the main season the nut weevil incidence was observed and the percentage of incidence ranged from 23.33to 56.66 (Table 7). The individual effect of spacing and pruning on nut weevil incidence was highly significant and the lower incidence was observed in the wider spacing where the trees were pruned. This may be due to the fact that the microclimate created by optimum light interception due to wide spacing and pruning was not conducive for this pest. Further, the pest escaping mechanism due to early flowering and fruiting might be an another reason for the low incidence.

The results of this present study have clearly indicated the benefit of heading back of 10 cm terminal shoots immediately after fruit harvest with paclobutrazol application to get higher yield in the main season besides heading back of 10 cm terminal growth after the emergence of new flush from December to January followed by paclobutrazol treatment in March / April which is useful to get major share of crop during off-season with good quality fruits.

Table 7: Effect of spacing, pruning and paclobutrazol (pp333) on nut weevil incidence (per cent) during main season

	S_1			S_2			S_3			S_4			T/	P_0/	P_1/
	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	P_0	P_1	Mean	Mean	Mean	Mean
T_0	36.67	36.66	36.67	46.66	36.66	41.66	50.00	43.33	46.67	56.66	46.66	51.66	44.16	47.49	40.83
T_1	30.00	23.33	26.67	33.33	33.33	33.33	36.66	40.00	39.99	40.00	43.33	40.00	35.00	34.99	34.10
T_2	46.66	36.66	41.66	43.33	43.33	43.33	46.66	46.66	46.66	50.00	50.00	50.00	45.42	46.66	44.16
Mean	37.77	32.22	**34.99**	41.11	37.77	**39.44**	44.45	44.45	**44.44**	48.89	45.55	**47.22**		**43.05**	**39.69**
	S			T		P	S x T			T x P			S x P		S x T x P
SE (d)	2.38			2.06		1.68	4.12			2.92			3.37		5.83
CD (0.05%)	4.79 **			4.15 **		NS	NS			NS			NS		NS

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