Original Research Article

Influence of NAA and Zinc sulphate on Fruiting behaviour and Quality of Litchi (Litchi chinensis Sonn.) cv. Rose Scented

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Abstract:

The current study was evaluated the effect of NAA and zinc sulphate to maintain fruiting behaviour and qualitative attributes of fruit in litchi cv. Rose scented. This experiment was done in 2022 and 2023 at the Horticulture Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.). There were sixteen treatments including four levels of zinc sulphate (0, 0.2, 0.4 and 0.6 %), NAA (0, 25, 50 and 75 ppm) and their combinations imitated in Factorial- CRD. The foliar application of treatments was done on January 28 and March 16 of each year, before flowering and fruit setting at pea stage, respectively. This experiment showed that the treatment with NAA 50ppm and 0.4% zinc sulphate improved fruit set (63.40 and 62.73%), fruit retention (30.76 and 31.36 %) and reduced fruit drop (69.23 and 68.63 %). The same treatment blend increased juice content of litchi fruit (63.63 and 64.22 percent) and also improved nutritional qualities of fruit like TSS (22.75 and 22.62 ^{0}Brix), total sugar (14.48 and 14.54 percent), ascorbic acid (41.22 and 41.64 mg/ 100g of pulp), organoleptic test (85.36 and 86.82) and minimum titratable acidity (0.473 and 0.421 percent) in litchi fruits.

Keywords: Litchi, NAA, $ZnSO_4$, fruiting behavior and quality attributes.

Introduction

Litchi (*Litchi chinensis* Sonn.) is a very important subtropical evergreen fruit crop, belonging to the family Sapindaceae. It is a nut type of fruit cultivated commercially to a limited extent in Bihar, Uttarakhand, Assam, West Bengal, Orissa, Tripura, and Himachal Pradesh and also grown in sub- mountainous districts of Uttar Pradesh i.e., Saharanpur and Muzaffarnagar (Singh and Singh, 1954; Gautam *et al.,* 2021). Muzaffarpur of Bihar grows best quality litchi fruits. The litchi fruits also known as "Natural rasgulla" are considerably rich in

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The current study investigation was led to evaluated the effect of NAA and zinc sulphate to maintain fruiting behaviour and qualitative attributes of fruit in litchi cv. Rose scented. This experiment was done in 2022 and 2023 at the Horticulture Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.). There were sixteen treatments including four levels of zinc sulphate (0, 0.2, 0.4 and 0.6 %), NAA (0, 25, 50 and 75 ppm) and their combinations imitated in Factorial- CRD. The foliar application of treatments was done on January 28 and March 16 of each year, before prior to flowering and fruit setting at pea stage, respectively. This experiment showed that the treatment with NAA 50ppm and 0.4% zinc sulphate improved fruit set percent (63.40 and 62.73%), fruit retention percent (30.76 and 31.36 %) and reduced fruit drop percent (69.23 and 68.63 %). The same treatment blend increased juice content of litchi fruit (63.63 and 64.22 percent) and also improved nutritional qualities of fruit like TSS (22.75 and 22.62 ^{0}Brix), total sugar (14.48 and 14.54 percent), ascorbic acid (41.22 and 41.64 mg/ 100g of pulp), organoleptic test (85.36 and 86.82) and minimum titratable acidity (0.473 and 0.421 percent) in litchi fruits.

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Introduction

Litchi (*Litchi chinensis* Sonn.) is a very important subtropical evergreen fruit crop, belonging to the family Sapindaceae family. IBotanically, it is a nut type of fruit cultivated commercially to a limited extent in Bihar, Uttarakhand, Assam, West Bengal, Orissa, Tripura, and Himachal Pradesh and also . It is grown in sub- mountainous districts of Uttar Pradesh i.e., Saharanpur and Muzaffarnagar (Singh and Singh, 1954; Gautam *et al.*, 2021). Muzaffarpur of Bihar grows best quality litchi fruits. The litchi fruits also known as "Natural rasgulla" are

Commented [Ma7]: Vague sentence. Pleae rephrase it considerably rich in the sugar. The sugar content of different varieties ranges from 6.74 to 18.86 percent. In addition to sugar, it contains 0.7% pectin, 0.3% minerals and 40-60 mg vitamin C per 100 g of pulp.

Litchi fruit is a delicious and luscious ~~fruit~~ with attractive red colo~~u~~r, sweet aroma and good taste (Hossain *et al.*, 2014). It is a sweet, dry fruit with white translucent juicy pulp and large seeds. The taste of fresh fruit pulp is musky and ~~. W~~when dried, it has a sour taste and is very sweet. It is rich in carbohydrates, vitamins, and minerals such as magnesium, iron, calcium, copper, phosphorus, and potassium. It is processed into juice, wine, pickles, jam, jelly, ice cream, yogurt (Huang *et al., 2005;* Nand *et al.*, 2023).

For years, plant growth regulators (PGRs) and micronutrients have consistently boosted economic returns in litchi production by influencing fruit behaviour and plant growth. Both micronutrients and PGRs positively impact lychee fruit yield and quality, enhancing flowering, fruit set, and retention. Optimal micronutrient concentrations stimulate plant growth, increase yield, and improve fruit quality. Foliar applications are essential for providing specific micronutrient requirements. Zinc plays a crucial role in plant metabolic activities, acting as a metal activator for enzymes and influencing RNA and ribosome content. Zinc deficiency adversely affects flowering, fruit size, growth, and quality. Auxin significantly affects respiration, photosynthesis, and osmotic pressure, leading to changes in fruit qualities. Recognizing the significance of zinc and NAA in litchi, this experiment was designed.

Material Methods

The litchi trees were about 30 years old but properly maintained at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology Kanpur. Sixteen uniform plants of litchi 'cultivar Rose scented' were selected for the present investigations during 2022 and 2023. During the course of the investigation the whole orchard was kept under clean and uniform cultivation. Factorial Completely Randomized Design was used with three replications and sixteen treatments viz., four levels each of NAA (0, 25, 50 and 75 ppm) and zinc sulphate (0, 0.2, 0.4 and 0.6%) and their combination spraying of these were done twice i.e., before flowering (28 January) and at pea stage (16 March) during both the years. Three branches in uniform growth and vigour were selected on each tree.

Observations were recorded on various fruiting and quality parameters. The length and diameter were determined with the vernier callipers, fruit weight, pulp weight, seed weight and rind weight of fruit was determined with the help of electronic balance. The total sugars and

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titratable acidity contents were determined by the techniques as recommended by AOAC (1980).

Results and Discussion

Fruit Set (per panicle): Correlative influence of NAA and Zinc was found to be non-significant. Treatment of N_2Z_2 induced maximum (258.90 and 259.41) fruit set closely followed by treatment N_2Z_3 (256.33 and 257.40). The minimum (212.50 and 214.51) fruit set were presented with control (N_0Z_0) during both years of experimentation. The chemical significantly increased the fruit set as compared to control however, the highest fruit set was obtained with the application of 0.4 per cent zinc sulphate + 50 ppm NAA. It has been early reported that fruit set in pear can be promoted with application of plant bio-regulators like NAA in litchi. These results corroborate with the work of in litchi. The increases in number of inflorescence and fruit set with zinc application Saraswat *et al*. (2006), might be due to its effect on process of fertilization and hormonal metabolism, helpful in maintaining better nutritional status of tree which ultimately proved beneficial in improving fruit set.

Fruit Drop (%): Interactive influence of NAA and Zinc was found to be non-significant, treatment of N_2Z_2 resulted minimum (69.23 and 68.63 %) fruit drop closely followed by treatment N_2Z_3 (70.26 and 69.58%). The maximum (77.57 and 77.17 %) fruit drop were presented with control (N_0Z_0) during both the years of experiments. The chemical non-significantly reduced the fruit drop as compared to control however, the lowest fruit drop was obtained with the application of 0.4 per cent zinc sulphate + 50 ppm NAA. These outcomes also agree with the conclusions of Saraswat *et al.* (2006). In mature fruits, pre-harvest drop is caused by low auxin levels and a weakening and eventual fracturing of the middle lamella of the cell at or near the abscission layer. Therefore, the fruit is not affected by these alterations in the middle lamella when auxin is applied; this is probably because auxin inhibits the enzymes that make pectin soluble. Applying zinc sulphate foliarly at a reasonable dosage may aid to keep plants in a healthier nutritional state, which will ultimately improve fruit retention and prevent drop.

Fruit Retention (%): Correlative consequence of NAA and Zinc was found to be non-significant treatment of N_2Z_2 induced maximum (30.76 and 31.36 %) fruit count at maturity stage closely followed by treatment N_2Z_3 (29.74 and 30.47 %). The minimum (22.42 and 22.83%) fruit retention were recorded with control (N_0Z_0) during both the years. Zinc response was more positive which play an important role in translocation of carbohydrates, auxin synthesis and increased pollen viability and fertilization. Minimum fruit setting and fruit retention were recorded under control. Similar results were also observed in litchi under Saraswat *et al*. (2006), Chaudhary *et al.* (2018). Fruit retention increased and fruit drop was reduced with the usage of NAA.

Fruit quality:

Juice Content (%): In relation to different NAA and Zinc concentrations on initial juice are an expression the plants which was influenced by NAA and Zinc growth regulators over control. Interactive effect of NAA and Zinc was found non-significant under treatment of N_2Z_2 that induced maximum (63.63 and 64.22 %) juice content closely followed by treatment N_2Z_3 (62.57 and 63.64 %). The minimum (53.22 and 53.81 %) juice content were presented with control (N_0Z_0) during both the years of experiments. This increase may be ascribed to enhance synthesis of metabolites, increased absorption of water and mobilization of sugars and minerals in the expanded cells and intercellular space of mesocarp. These enhancements of above physiological activities are accelerated possibly due to growth promoter as well as nutrients also. Improvement in juice content with the use of NAA and $ZnSO_4$ has been observed. These results are in accordance with the reports of Nand *et al.* (2023) in litchi.

Total Soluble Solid Content (^{0}Brix): Relative to different NAA and Zinc concentrations on initial TSS are an expression the plants which was influenced by NAA and Zinc over control. The associated consequence of NAA and Zinc was found to be non-significant treatment of N_2Z_2 induced maximum (22.75 and 22.62 ^{0}B) TSS closely followed by treatment N_2Z_3 (22.34 and 22.44 ^{0}B). The minimum TSS (18.32 and 18.24 ^{0}B) was presented with control (N_0Z_0) during both the years of experiments. The reason for increase in total soluble solids content of fruit may be due to fact that nutrients and plant growth regulators played important role on photosynthesis which ultimately led to the accumulation of carbohydrates and attributed to increase in T.S.S. of fruit. These results are in similar with the finding of $ZnSO_4$ and NAA may be attributed to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to developing fruits. The results with respect to quality are in accordance with the findings of Chaudhary *et al.* (2018), Sharma *et al.* (1987), Saraswat *et al.* (2006), Gupta *et al.* (2022) in litchi and Shukla *et al.,* Katiyar *et al.* (2008) in aonla. The process of photosynthesis and the mobilization of food material were greatly aided by NAA and zinc sprays. This resulted in the accumulation of quality constituents such as carbohydrates, which in turn promoted the quality attributes and the rapid metabolic conversion of starch and pectin into soluble compounds and the translocation of sugars from leaves to developing fruits (Brahamachari and Rani, 2001).

Total sugar content: In regard to various NAA and Zinc fixations on starting absolute sugar are an articulation the plants which was affected by NAA and Zinc development controllers over control. Treatment with N_2Z_2 (14.48 and 14.54 percent) was found to have a non-significant and greater effect on total sugar than treatment with N_2Z_3 (14.23 and 14.32 percent). During both of the years of the experiments, the control (N_0Z_0) was given the minimum total sugar (11.42 and 11.54 percent). Decline in acridity with foliar use of $ZnSO_4$ and NAA may be because of expansion in movement of carb and increment metabolic change from acridity to sugars. Singh *et al*, (2017) in mango, Tiwari *et al.* (2017) in aonla, Shukla *et al.* (2011), Saraswat *et al.* (2006), Kaur (2017), Devaraja *et al.* (2019) in litchi reports are in line with these findings.

Titratable Acidity: Different quantities of zinc and NAA at harvest time indicate how the plants were affected by these growth regulators, which had an impact on the plants' ability to titrate acidity. The combined effects of zinc and NAA were shown significant. At harvesting, N_2Z_2 considerably reduced the acidity to a minimum of (0.473 and 0.421 percent), closely followed by N_2Z_3 treatment (0.476 and 0.425 percent). The control group (N_0Z_0) was used to demonstrate the greatest acidity at harvest (0.628 and 0.617 percent) in both trial years. These results are consistent with the reports in Singh *et al*, (2017) in mango, Litchi by Saraswat *et al.* (2006), and Megu *et al.* (2021) and Tripathi *et al.* (2011) in aonla. This indicates that juice acidity was inclined to be reduced by the high quantity of NAA present in the zinc sprays.

Ascorbic Acid: The results regarding the various sprays of NAA and Zinc on litchi trees showed ascorbic acid content as follows. Treatment with N_2Z_2 (41.22 and 41.64 percent) was found to have a non-significant effect on ascorbic acid than the treatment with N_2Z_3 (39.96 and 41.22 percent). During both of the years of the experimentation, the control (N_0Z_0) was given the minimum ascorbic acid (32.64 and 33.26 percent). Interactive effect of NAA and Zinc on the ascorbic acid content of litchi fruit might be due to the increase in synthesis of metabolites which can enhance the synthesis of ascorbic acid precursor. The reports of Saraswat *et al*. (2006), Devaraja *et al.* (2019), Megu *et al*. (2021) in litchi are in line with these findings.

Organoleptic Test (%): The organoleptic test is an evaluation of the fruit's taste and aroma, which was influenced by NAA and Zinc over control. Joint effect of NAA and Zinc was found to be non-significant treatment of N_2Z_2 induced significantly maximum (85.36 and 86.82%) organoleptic values closely followed by treatment N_2Z_3 (84.76 and 85.45%). The minimum values (71.23 and 72.31%) were recorded with control (N_0Z_0) during both the years of experiments. These findings are in accordance with the reports of Nand *et al.,* (2023) in litchi Devaraja *et al.,* (2019) in litchi.

CONCLUSION

Based on results acquired in the current experiment it could be presumed that the utilization of NAA and Zinc came out with improved fruiting and good quality of litchi crediting characters such as length, diameter and weight of fruit which at last expanded the yield per plant under combination of NAA 50ppm and Zinc 0.4%. This treatment likewise worked on wholesome characteristics of fruit like total sugars and decreased acidity and maintained sugar acid ratio in litchi. The application of plant bio-regulators (NAA) and micronutrients ($ZnSO_4$) plays a significant role in enhancing fruit yield and quality by reducing cracking and enhancing fruit set, retention, and quantity. because litchi is an important fruit crop in subtropical climates in India. That is the reason from here on out, more experimental researches can be done on different cultivars, alone or in the mix of both plant growth regulators and micro-nutrients on additional boundaries to normalize dosages well defined for the specific districts.

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Table no. 1: Effect of foliar sprays of NAA, Zinc and their interactions on fruits set, drop and retention.

Parameter	Doses	Zinc % (B)									
	NAA	2022					2023				
	ppm (A)	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A
Fruit Set percent	A_0 Control	54.343	54.827	55.070	55.480	54.930	54.743	55.117	56.590	56.900	55.838
	A_1 25	55.597	56.047	56.640	56.787	56.268	56.967	57.717	58.240	58.323	57.812
	A_2 50	60.730	61.537	63.407	62.730	62.101	61.970	62.177	63.507	62.430	62.521
	A_3 75	57.793	58.270	59.650	60.373	59.022	59.183	61.070	61.030	61.323	60.652
	Mean B	57.116	57.670	58.692	58.843		58.216	59.020	59.842	59.744	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.130	0.552	0.391			1.134	0.554	0.392		
	B	1.130	0.552	0.391			1.134	0.554	0.392		
	A X B	NS	1.105	0.781			NS	1.108	0.784		
Fruit Drop percent	A_0 Control	77.577	76.223	75.500	75.140	76.110	77.177	76.703	76.600	75.140	76.405
	A_1 25	75.223	74.783	74.360	74.113	74.620	74.873	74.443	73.280	73.227	73.956
	A_2 50	70.323	70.310	69.233	70.260	70.032	70.090	69.580	68.633	69.523	69.457
	A_3 75	73.267	72.430	71.580	71.337	72.153	72.767	71.110	70.950	70.737	71.391
	Mean B	74.098	73.437	72.668	72.713		73.727	72.959	72.366	72.157	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.126	0.550	0.389			1.136	0.555	0.392		
	B	1.126	0.550	0.389			1.136	0.555	0.392		
	A X B	NS	1.101	0.778			NS	1.110	0.785		
Fruit Retention percent	A_0 Control	22.423	23.777	24.500	24.860	23.890	22.823	23.297	23.400	24.860	23.595
	A_1 25	24.777	25.217	25.640	25.887	25.380	25.127	25.557	26.720	26.773	26.044
	A_2 50	29.677	29.690	30.767	29.740	29.968	29.910	30.420	31.367	30.477	30.543
	A_3 75	26.733	27.570	28.420	28.663	27.847	27.233	28.890	29.050	29.263	28.609
	Mean B	25.903	26.563	27.332	27.288		26.273	27.041	27.634	27.843	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.126	0.550	0.389			1.136	0.555	0.392		
	B	1.126	0.550	0.389			1.136	0.555	0.392		
	A X B	NS	1.101	0.778			NS	1.110	0.785		

Table no. 2: Effect of foliar sprays of NAA, Zinc and their interactions on TSS, Total sugars and Titratable acidity.

Parameter	Doses	Zinc % (B)									
	NAA	2022					2023				
	ppm (A)	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A
Total Soluble Solids (TSS)	A_0 Control	18.323	18.450	18.683	18.873	18.583	18.243	18.820	19.120	19.360	18.886
	A_1 25	19.050	19.260	19.450	19.920	19.420	19.590	19.680	19.957	20.180	19.852
	A_2 50	21.557	21.880	22.750	22.340	22.132	21.420	21.727	22.620	22.440	22.052
	A_3 75	20.237	20.560	20.850	21.150	20.699	20.353	20.910	20.460	20.650	20.593
	Mean B	19.792	20.038	20.433	20.571		19.902	20.284	20.539	20.658	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.504	0.246	0.174			0.493	0.241	0.170		
	B	0.504	0.246	0.174			0.493	0.241	0.170		
	A X B	NS	0.493	0.348			NS	0.482	0.341		
Total Sugars	A_0 Control	11.423	11.650	11.870	11.953	11.724	11.540	11.883	12.053	12.140	11.904
	A_1 25	12.230	12.350	12.590	12.783	12.488	12.253	12.400	12.650	12.870	12.543
	A_2 50	13.650	13.920	14.483	14.233	14.072	13.950	14.150	14.543	14.320	14.241
	A_3 75	12.850	13.037	13.180	13.470	13.134	13.167	13.450	13.583	13.740	13.485
	Mean B	12.538	12.739	13.031	13.110		12.728	12.971	13.208	13.268	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.278	0.136	0.096			0.280	0.137	0.097		
	B	0.278	0.136	0.096			0.280	0.137	0.097		
	A X B	NS	0.272	0.192			NS	0.273	0.193		
Titratable Acidity	A_0 Control	0.628	0.582	0.542	0.526	0.569	0.617	0.573	0.562	0.532	0.571
	A_1 25	0.517	0.515	0.513	0.508	0.513	0.512	0.512	0.506	0.505	0.509
	A_2 50	0.485	0.482	0.473	0.476	0.479	0.455	0.448	0.421	0.425	0.437
	A_3 75	0.506	0.505	0.498	0.493	0.500	0.498	0.475	0.462	0.459	0.473
	Mean B	0.534	0.521	0.507	0.501		0.520	0.502	0.488	0.480	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.012	0.006	0.004			0.010	0.005	0.003		
	B	0.012	0.006	0.004			0.010	0.005	0.003		
	A X B	0.025	0.012	0.009			0.020	0.010	0.007		

Table no. 3: Effect of foliar sprays of NAA, Zinc and their interactions on Juice content, Ascorbic acid and Organoleptic test.

Parameter	Doses	Zinc % (B)									
	NAA	2022					2023				
	ppm (A)	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A	B_0 Control	B_1 0.2	B_2 0.4	B_3 0.6	Mean A
Juice Content	A_0 Control	53.223	53.827	54.300	54.960	54.078	53.813	54.367	55.073	55.260	54.628
	A_1 25	55.397	56.137	57.060	57.073	56.417	55.477	56.537	57.000	56.990	56.501
	A_2 50	60.780	61.597	63.637	62.570	62.146	61.720	62.447	64.227	63.640	63.008
	A_3 75	57.693	58.450	58.850	59.283	58.569	58.617	58.960	59.890	60.683	59.538
	Mean B	56.773	57.503	58.462	58.472		57.407	58.078	59.048	59.143	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.138	0.556	0.393			0.438	0.214	0.151		
	B	1.138	0.556	0.393			0.438	0.214	0.151		
	A X B	NS	1.112	0.787			NS	0.428	0.303		
Ascorbic Acid	A_0 Control	32.643	33.097	33.423	33.710	33.218	33.263	34.397	35.563	35.790	34.753
	A_1 25	34.217	34.737	35.660	35.633	35.062	36.067	36.477	37.030	37.043	36.654
	A_2 50	38.700	39.437	41.227	39.960	39.831	40.300	40.737	41.647	41.220	40.976
	A_3 75	36.517	36.930	37.910	38.573	37.483	37.757	38.330	38.920	40.003	38.753
	Mean B	35.519	36.050	37.055	36.969		36.847	37.485	38.290	38.514	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	0.439	0.215	0.152			0.438	0.214	0.151		
	B	0.439	0.215	0.152			0.438	0.214	0.151		
	A X B	NS	0.429	0.303			NS	0.428	0.303		
Organoleptic Test	A_0 Control	71.233	71.777	72.260	73.610	72.220	72.313	72.907	73.380	74.710	73.328
	A_1 25	74.447	75.627	76.420	76.820	75.828	75.527	76.777	77.860	78.117	77.070
	A_2 50	82.730	83.737	85.367	84.760	84.148	83.610	84.897	86.827	85.450	85.196
	A_3 75	78.433	79.870	80.540	81.663	80.127	79.193	80.670	81.950	82.813	81.157
	Mean B	76.711	77.753	78.647	79.213		77.661	78.813	80.004	80.273	
	Factors	CD at 5%	SE (d) ±	SE (m) ±			CD at 5%	SE (d) ±	SE (m) ±		
	A	1.121	0.548	0.388			1.126	0.550	0.389		
	B	1.121	0.548	0.388			1.126	0.550	0.389		
	A X B	NS	1.096	0.775			NS	1.100	0.778		