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Effect of Vine Cutting Length and Angle of Planting on the Growth and Yield Performance of Sweet Potato in Makurdi, Southern Guinea Savannah Agro-Ecological Zone of Nigeria

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Abstract: **Field trials were conducted during 2014 and 2015 cropping seasons at the teaching and Research farm of the Federal University of Agriculture, Makurdi in Benue State located in the southern guinea Savanna of Nigeria to evaluate the effect of vine cutting length and angle of planting on the growth and yield performance of sweet potato. The experiment was a 3x4 factorial laid out in randomized complete block design with three replications. Three vine lengths of sweet potato (20cm, 30cm and 40cm) and four angles of planting [45^{o} (incline) 90^{o} (vertical) 180^{o} (horizontal) and 360^{o} (ring)] were used. In both years, result showed that all growth components (vine length, number of leaves, number of branches and fodder weight) and yield components (root girth, root length, salable and unsalable root number and salable and unsalable root weight) and net yield were significantly ($P \leq 0.05$) increased as the length of planting material was increased. The result also showed that root girth, root length, number of salable root, weight of salable root and net yield were significantly ($P \leq 0.05$) decreased with increased in angle of planting, whereas unsalable root number and unsalable root weight were significantly ($P \leq 0.05$) increased with increased in angle of planting. The ring method of planting produced higher number of leaves, branches, unsalable roots, weight of unsalable roots and fodder weight.**

Keywords: **Angle of planting, growth, yield performance, Guinea Savanna, Sweet potato, vine length.**

1. INTRRODUCTION

Sweet potato (*Ipomoea batatas* .L) is an important staple food crop worldwide due to its high yield and wide adaptation (Bouwkamp, 1985). It ranks as the world seventh most important crop with an estimated annual production of 300 million metric tons grown over 19 million hectares of land (Amamgbo and Nwankwu, 2008). It ranked third in production area among the root and tuber crops, following cassava and yam in Nigeria (Anyaebunam *et al*., 2008).

Sweet potato has become an attractive crop among farmers due to its high productivity, universal usage, calorie content and good taste (Antibong *et al*., 2008). Researches revealed sweet potato as a weapon against diabetes as a result of its low glycemic index **(**Bradley, 2009). Williams *et al*.(2013) .reported that sweet potato leaves contain chlorogenic acids, a phenolic compound responsible for suppressing obesity in humans.

There have been attempts to increase yield of sweet potato through modification of cutting characteristics, the length of vine cuttings has significant effect on the yield of sweet potato and length used varies from farmer to farmer and location to location. Achebe *et al*. (2015) experimented on vine lengths of 20cm, 25cm and 30cm and discovered that vine length of 30cm performed better than the others. A vine length of 20 – 40cm with at least 3 – 5 nodes was found to be optimum for the storage root production in the different parts of India (Nair, 2006). In Cuba, 25 – 30cm long stem cuttings were found to be ideal (Sandchez *et al*., 1985) and studies on planting materials in Bangladesh showed that increasing the length of vine/nodes increase number of vines, vine length and yield.

The angle of planting also varies among farmers and location. In Nigeria, sweet potato farmers plant the crop either horizontally, vertical, at an incline angle or in ring form. The most suitable vine length for propagation and angle of placement for maximum yield has been argued among researchers. Dhliwago and Chiunzi (2004) stipulated that planting at an angle or horizontally produced more yield while Onweme and Sinha (1991) recommends vertical orientation. Owueme (1978) indicated that tuber yield tend to increase with increase in length of vine cutting while Baustita and Vega (1991) recommends 40 – 45cm vine cuttings. Information regarding cutting characteristics for the establishment of sweet potato in South Guinea Savanna is scarce, therefore, this experiment was conducted to compare and quantify the effect of cutting length and planting position on the growth and yield of sweet potato in Southern Guinea Savanna of Nigeria.

2. MATERIALS AND METHODS

STUDY AREA:

Field trials were conducted during 2014 and 2015 cropping seasons at the teaching and Research farm of the federal University of Agriculture, Makurdi (Latitude 07^o 45' – 07^o 50' N, Longitude 08^o 45' – 08^o 50' E, elevation 98m) in Benue State located in the southern guinea Savanna of Nigeria to evaluate the effect of vine length and angle of planting vine cutting on the growth and yield performance of sweet potato.

EXPERIMENTAL DESIGN AND TREATMENT:

The experiment was a 3x4 factorial laid out in randomized complete block design with three replications. Three vine lengths of sweet potato (20cm, 30cm and 40cm) and four angles of planting [45^o (incline) 90^o (vertical) 180^o (horizontal) and 360^o (ring)].were used. Sweet potato variety used was obtained from national Root Crops Research Institute (NRCRI) Umudike.

AGRONOMIC PRACTICES:

The land was manually cleared and ridged using cutlasses and hoes. Ridges were constructed 1m apart. Gross plot consisted of 5 ridges 3m long ($15m^2$) and the net plot was made up of inner three ridges ($9m^2$) Sweet potato vine cutting measuring 20cm, 30cm and 40cm were plant at the crest of the ridges at different planting angles of 45^o (incline) 90^o (vertical 180^o (horizontal and at 360^o (ring) and spaced 30cm (33, 000 plants/ha). All plots received basal application of 300kg NPK 15:15:15 per hectare (BNARDA, 2003). Two manual weeding were done at 3 and 6 weeks after planting (w. a. p) using hoes. The crop was harvested at physiological maturity when most of the leaves had turned yellow.

3. DATA COLLECTION AND ANALYSIS

Data on vine length, number of leaves and number of branches was collected at 4^{th} and 8^{th} weeks after planting (w. a. p). At harvest, data on fodder weight, root girth, root length, number and weight of salable and unsalable roots and net yield t/ha were collected. The data generated were analyzed using GENSTAT statistical software. Fisher 's least Significant Differences (FLSD) was used for mean separation at the probability level of 5% whenever differences between treatment means were significant.

4. RESULT AND DISCUSSION

VINE LENGTH:

Result on sweet potato vine length (Table 1) showed that there was significant ($P\leq 0.05$) difference in vine length among the different length of vine cuttings used. Vine lengths of 2015 were longer than those of 2014 which might be due to higher rainfall experienced in 2015 than 2014 which may have influenced the vine length. Rasco and Amante (2000) reported that field and environmental condition may influence the relationship between cutting length and growth and yield components of sweet potato. Vine length increased with increased in length of cutting. Ray *et al.* (2001) and Nedunchezhiyan *et al*.(2012) reported increased vine length as the length of cutting was increased.

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There was significant ($P \leq 0.05$) reduction in vine length as the angle of planting was increased. This finding is in line with that of Wilson (1988) who reported that decreasing inclination of cuttings increase vine length but at variance with findings of Parwada *et al*. (2016) who observed increased in vine length as angle of inclination was increased.

Vine length x angle of planting interaction is as presented on Table 2. Irrespective of the length of cutting , vine length decreased with increased in angle of planting.

Number of branches:

The result on number of branches showed that number of branches increased significantly ($P \leq 0.05$) with increased in length of cuttings. Beyene *et al*.(2015) also found significant influence of vine nodes/length of cutting on number of branches of sweet potato. This increase in number of branches as a result of increase in length of cutting might be due to increase in the number of nodes available for branches initiation, this result also agreed with the findings of Amoah (1997) who reported more stem production as a result of increase in cutting length. There was significant ($P \leq 0,05$) difference in number of branches among the various angle of planting employed. This might be as a result of exposing more nodes to light which may activate branching initiation while the less incline cutting nodes may respond to root initiation because of closeness to the ground. Bose *et al.* (2003) observed fewer branches as angle of inclination decreases and attributed this to root initiation responding positively to geotropism. The interaction effect of length of cutting x angle of planting showed significant effect. 40cm length at ring planting produces the highest number of branches. Regardless of the length of vine used, number of branches increased with increased in angle of planting sweet potato cuttings.

NUMBER OF LEAVES:

The main effect of number of leaves of sweet potato as influence by length of cutting and angle of planting and the interaction effect of length of cutting x angle of planting was significant ($P \leq 0.05$). Regardless of the week evaluated, cutting length of 40cm gave significantly higher number of leaves than any other cutting length. The superior performance of this treatment could be attributed to the numerous nodes available for branching and leaves initiation. This result conformed to the work of Essilfie *et al*. (2016) who reported increase in leave numbers of longer vines as a result of higher number of branches produced.

FODDER WEIGHT (T/HA):

Main effect of fresh and dry fodder weight of sweet potato as influenced by length of cutting and angle of planting and their interaction effect for 2014 and 2015 is as shown on table 3 and 4. Fresh and dry weight of sweet potato was significantly influenced by length of cutting and angle of planting. Fresh and dry fodder weight increased with increased in length of cutting with 40cm length producing the highest fodder weight. Also, fresh and dry fodder weight increased with increased in angle of planting with ring planting producing highest fresh and dry fodder weight. The increase in fodder weight as a result of increase in length of cutting and angle of planting could have resulted from the numerous branches formed that contribute to production of more biomass. This result is in line with Amoah (1997) who attributed increase in fodder weight to increase number of branches and Beyene *et al*. (2015) who observed significant increase in biomass as length of planting material was increase.

ROOT GIRTH:

Data presented on table 3 showed significant ($P \leq 0.05$) effect of length of cutting and angle of planting on root girth for 2014 and 2015 cropping seasons. Root girth increased with increased in length of cutting and decreased as angle of planting was increased. The increase in root girth as a result of increase in length of cutting might be due to higher number of branches formed on longer cuttings which might have increase the quantity of photosynthate sent to the sink from the factories (leaves). Parwada *et al*. (2011) reported increased root girth with decreased in angle of planting.

ROOT LENGTH:

Root length of sweet potato as influenced by length of cutting , angle of planting and the interaction effect of length of cutting x angle of planting was significant (Table 3 and 4). Root length of sweet potato increased with increased in length of cutting planted but decrease with increase in angle of planting. This finding is in line with the work of Parwada *et al*. (2011) who reported increase in root length with decrease in cutting inclination. The longest root length was recorded when 40cm vine cuttings were planted at an angle of 45^{o}(incline) and the shortest root length was obtain when 20cm vine cutting was used and planted at an angle of 180^{o} (horizontal).

SALABLE AND UNSALABLE ROOT NUMBER:

Table 5 showed that salable and unsalable root numbers were significantly ($P \leq 0.05$) influenced by length of cutting and angle of planting. Salable and unsalable root number increase with increase in length of cutting with 40cm length recording highest number. This might be to shorter vines having fewer nodes buried while longer vine cuttings having more nodes buried and more roots are initiated from the nodes. Essilfie *et al.* (2016) reported that in higher nodes number cutting, early rapid growth, tuber initiation and bulking began earlier than lower number cuttings which translate into higher root yield. However, findings of Belehu (2003) reported no significant effect of cutting length on storage root number. Salable roots decreased with increased in angle of planting whereas unsalable root number increased with increased in angle of planting.

The interaction (Table 6) effect showed that in 2014, when 20cm cutting was used, ring planting produced the highest salable and unsalable root numbers. However, when 30cm and 40cm cuttings were used, 45^o inclination produced highest number of salable roots and ring planting recorded highest in unsalable root numbers. Whereas in 2015, irrespective of the length of cutting, number of salable roots decrease with increase in angle of planting and unsalable roots increase with increase in angle of planting.

SALABLE AND UNSALABLE ROOT WEIGHT (T/HA):

Table 5 and 6 presents the main effect of vine length cutting, angle of planting and their interaction effect on salable and unsalable root weight for 2014 and 2015 cropping seasons. There was significant ($P \leq 0.05$) difference among the various lengths of cutting used with 40cm cutting producing highest salable and unsalable root weight tones per hectare. This higher salable and unsalable root weight might be due to the numerous nodes of longer vine cuttings which might have produced more branches and more storage roots, Choubury *et al*. (1986) found the same result when he worked on effects of number of nodes on sweet potato. Hall (1986) observed significantly greater total storage root weight with 40 – 45cm than 20 – 25cm cuttings; Also, Baustita and Vega (1991) reported that cuttings of intermediate length (40cm) produced better storage root weight than shorter or longer cuttings.

Salable root weight decreases with increase in angle of planting while unsalable root weight increases with increase in angle of planting. This might be due to better light interception by the incline cuttings which most have resulted in production of more photosynthates to the sink. This result agreed with the findings of Boote and Loomis (1992) who reported that light interception efficiency was higher for incline arrange leaves but lower for vertical leaves arrangement which allows for rapid reallocation of resources between the shoot and the root system. Dayal and Sharma (1991) also reported that vertical planting result in higher salable yield over horizontal.

NET YIELD (T/HA):

Result on net yield tones per hectare 2014 and 2015 is as presented in Table and 5. Vine length of 40cm significantly produced higher net yield (t/ha) than the other cuttings. There was significant difference among the length of vine cuttings used. Yield increased with increased in vine cutting planted, This might be due to the numerous nodes that might have initiated more roots. This result agreed with that of Hall (1986); Baustita and Vega (1991) and Essilfie *et al.* (2016) who reported that tuber yield tend to increase with increase in the length of vine cutting used.

Net yield decreased with increased in angle of planting. This might be due to higher photosynthates production of incline leaves because of much light interception. Parwada *et al.* (2011) reported higher yield in incline cuttings than vertical and horizontal.

In 2014, the interaction effect showed that 20cm cutting at an angle of 90^o (vertical) produced lowest net yield with no consistent trend, whereas for 30cm and 40cm vine cuttings, net yield decreased with increased in angle of planting. In 2015, irrespective of the vine cutting employed, yield decreased with increased in angle of planting. 2015 produced higher net yield than 2014. The higher net yield in 2015 season than 2014 season might be due to higher rainfall which might have resulted to more leaves that translate to higher photosynthate production. This is similar to the report of Kentgen *et al.* (2001) that storage root growth depend on the sink strength, the potential of leaves to export photosynthate and on the photosynthetic efficiency of the leaves.

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5. CONCLUSION

Vine length, number of leaves and number of branches of sweet potato increased as the length of planting material was increased. Vine length of 40cm produced highest root girth, root length, number of salable and unsalable roots, weight of salable and unsalable roots, fresh and dry fodder weight and net yield. The ring method of planting produced higher number of leaves, branches, number unsalable roots, weight of unsalable roots, fresh fodder weight and dry fodder weight. Planting at an angle of 45^o produced significantly higher vine length, root girth, root length, number of salable roots, weight of salable roots and net yield.

TABLE: I EFFECT OF LENGTH OF CUTTING AND ANGLE OF PLANTING ON VINE LENGTH, NUMBER OF LEAVES AND NUMBER OF BRANCHES OF SWEET POTATO IN 2014 AND 2015.

Treatment	Vine length				Number of leaves				Number of branches			
	4 WAP		8 WAP		4 WAP		8 WAP		4 WAP		8 WAP	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Vine length												
20cm	37.00	39.24	125.10	136.00	40.30	46.10	117.50	121.45	3.40	3.87	14.55	13.76
30cm	42.37	46.06	158.00	161.25	40.86	48.32	129.00	131.69	4.25	5.23	16.04	18.64
40cm	42.38	47.11	175.30	183.13	50.01	52.66	145.00	149.12	4.80	5.92	20.20	20.96
FLSD (0.05)	4.19	4.22	19.69	16.77	3.51	4.11	8.67	7.88	1.15	1.22	2.01	2.32
Angle of planting												
45^o (incline)	54.24	62.46	160.45	169.08	44.60	46.72	122.62	121.10	3.85	4.02	12.60	14.90
90^o (vertical)	54.15	61.90	157.20	162.62	45.01	48.82	120.86	133.04	4.01	4.88	11.95	17.00
180^o (horizontal)	47.45	56.44	125.20	147.25	52.35	55.50	145.52	146.23	5.66	6.64	18.42	23.65
360^o (ring)	46.46	56.00	123.45	142.00	54.44	56.70	148.55	152.45	6.10	7.34	20.02	24.43
FLSD(0.05)	1,24	1.19	3.50	3.65	2.10	2.30	2.45	2.68	2.26	2.01	4.45	4.64

FLSD = Fisher Least Significant Difference

TABLE: II INTERACTION EFFECT OF LENGTH OF CUTTING X ANGLE OF PLANTING ON VINE LENGTH, NUMBER OF LEAVES AND NUMBER OF BRANCHES OF SWEET POTATO IN 2014 AND 2015

Length of cutting	Angle of planting	Vine length				Number of leaves				Number of branches			
		4 WAP		8 WAP		4 WAP		8 WAP		4 WAP		8 WAP	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
	45^o (incline)	74.33	76.02	90.66	92.01	25.57	26.55	108.60	112.90	4.55	5.45	6.36	6.62
	90^o (vertical)	73.01	75.22	18.04	88.24	25.03	26.96	110.44	119.06	4.83	5.91	6.04	6.89
20cm	180^o (horizontal)	65.72	70.72	74.72	82.11	34.72	35.41	131.22	138.21	5.45	6.20	7.78	8.08
	360o (ring)	59.50	66.00	71.69	76.67	36.43	36.99	133.80	140.22	5.20	6.40	8.45	8.94
	45^o (incline)	76.39	79.41	102.43	117.11	39.58	38.19	110.90	117.10	4.55	5.07	7.62	8.70
	90^o (vertical)	74.17	76.36	98.50	101.04	36.60	40.18	115.25	122.00	5.38	5.89	8.56	8.99
30cm	180^o Horizontal)	71.07	73.17	78.70	96.23	42.06	43.03	144.52	142.60	6.01	6.55	9.85	10.06
	360^o (ring)	65.44	71.08	73.45	89.68	43.15	43.67	146.98	147.07	6.60	6.86	10.08	10.72
	45^o (incline)	83.94	88.50	110.38	141.60	45.54	42.48	121.84	120.20	5.22	5.48	8.20	9.10
	90^o (vertical)	78.72	79.27	104.46	116.70	42.83	46.18	115.32	123.40	5.01	5.88	9.10	9.66
40cm	180^o (horizontal)	73.60	77.00	80.62	96.61	46.10	46.88	148.05	150.18	7.50	7.90	10.52	11.42
	360^o (ring)	67.66	72.18	76.43	82.82	47.56	48.01	152.88	154.13	7.76	8.64	11.06	11.86
	FLSD (0.05)	8,38	7.92	24.38	18.74	6.01	5.36	18.24	16.77	0.18	0.22	0.27	0.36

FLSD = Fisher Least Significant Difference

TABLE:III EFFECT OF LENGTH OF CUTTING AND ANGLE OF PLANTING ON FRESH AND DRY FODDER WEIGHT, ROOT GIRTH AND ROOT LENGTH OF SWEET POTATO IN 2014 AND 2015.

Treatment	Fresh fodder weight t/ha		Dry fodder weight t/ha		Root girth (cm)		Root length (cm)	
	2014	2015	2014	2015	2014	2015	2014	2015
Vine cutting								
20cm	65.30	68.20	18.90	19.48	29.78	30.32	18.90	19.11
30cm	75.80	78.62	20.54	21.24	33.05	34.20	19.87	21.01
40cm	84.80	88.64	21.25	22.06	33.98	34.64	23.04	23.67
FLSD(0.05)	8.26	7.72	0.14	0.17	2.52	2.20	0.79	0.82
Angle of planting								
45^{o} (incline)	73.20	66.25	23.20	22.72	35.08	35.88	21.23	22.77
90^{o} (vertical)	65.00	74.00	22.60	23.86	33.69	34.01	20.77	22.21
180^{o} (horizontal)	87.80	89.76	24.87	25.32	30.23	31.47	20.77	21.68
360^{o} (ring)	90.00	92.15	25.87	26.07	30.19	31.16	20.03	21.33
FLSD (0.05)	9.54	8.82	0.93	0.88	2.91	2.84	0.84	0.92

FLSD = Fisher Least Significant Difference

Table: IV INTERACTION EFFECT OF LENGTH OF CUTTING X ANGLE OF PLANTING ON FRESH AND DRY FODDER WEIGHT, ROOT GIRTH AND ROOT LENGTH OF SWEET POTATO IN 2014 AND 2015.

Vine cutting	Angle 0f planting	Fresh fodder weight (t/ha)		Dry fodder weight (t/ha)		Root girth (cm)		Root length (cm)	
		2014	2015	2014	2015	2014	2015	2014	2015
	45^{o}(incline)	64.30	63.10	20.80	21.50	16.15	17.91	11.60	11.95
	90^{o} (vertical)	62.10	63.50	20.20	21.05	16.40	18.07	11.95	11.72
20cm	180^{o} (horizontal)	79.40	82.26	24.00	23.11	11.55	12.28	8.82	9.43
	360^{o} (ring)	85.50	86.11	25.20	25.01	10.08	10.96	9.02	9.08
	45^{o} (incline)	72.90	68.36	21.40	22.00	20.66	20.77	14.05	14.96
	90^{o} (vertical)	67.30	73.66	20.50	22.69	18.38	19.78	12.90	14.42
30cm	180^{o}(horizontal	75.80	77.80	21.90	22.86	12.25	13.69	10.70	13.69
	360^{o}(ring)	87.10	87.89	25.10	25.10	13.12	13.28	10.50	13.28
	45^{o} (incline)	76.40	74.45	22.00	23.64	23.20	23.89	18.10	18.88
	90^{o} (vertical)	73.50	77.41	23.30	24.24	21.44	22.33	16.66	17.40
40cm	180^{o} (horizontal)	89.10	91.00	25.80	26.01	16.52	17.42	15.74	16.76
	360^{o} (ring)	98.30	110.02	26.00	26.84	14.18	14.87	16.04	16.32
	FLSD (0.05)	6.52	7.02	110.27	9.11	5.32	6.22	2.16	2.44

FLSD = Fisher Least Significant Difference

TABLE: V EFFECT OF LENGTH OF CUTTING AND ANGLE OF PLANTING ON SALABLE AND UNSALABLE ROOT NUMBER, SALABLE AND UNSALABLE ROOT WEIGHT AND NET YIELD OF SWEET POTATO IN 2014 AND 2015

Treatment	Salable root number		Unsalable root number		Salable root weight (t/ha)		Unsalable root weight (t/ha)		Net yield (t/ha)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Vine cutting				1.82						
20cm	4.96	5.08	1.75	1.82	4.93	5.42	2.66	2.81	7.59	7.64
30cm	5.31	5.89	2.15	2.66	5.74	6.11	3.19	3.48	8.93	9.00
40cm	6.69	6.97	2.45	2.88	8.71	8.92	3.53	4.01	12.24	12.62
FLSD (0.05)	0.49	0.56	0.28	0.32	0.32	0.41	0.31	0.46	0.71	0.92
Angle of planting		6.46								
45^{o} (incline)	6.32	6.46	2.10	2.35	7.16	7.76	2.25	2.35	9.46	9.78
90^{o} (vertical)	6.03	6.20	2.72	2.85	6.71	7.11	2.40	2.65	9.11	9.36

180° (horizontal)	5.79	5.94	3.25	3.50	6.38	6.69	3.08	3.20	9.06	9.22
360° (ring)	5.27	5.43	3.32	3.60	5.59	6.19	3.29	3.32	8.88	8.97
FLSD (0.05)	0.57	0.61	0.57	0.80	0.37	0.42	0.37	0.41	0.82	0.90

FLSD = Fisher Least Significant Difference

TABLE: VI INTERACTION EFFECT OF LENGTH OF CUTTING X ANGLE OF PLANTING ON SALABLE AND UNSALABLE ROOT NUMBER, SALABLE AND UNSALABLE ROOT WEIGHT AND NET YIELD OF SWEET POTATO IN 2014 AND 2015

Vine cutting	Angle 0f planting	Salable root number		Unsalable root number		Salable root weight (t/ha)		Unsalable root weight (t/ha)		Net yield (t/ha)	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
	45°(incline)	4.60	4.80	2.58	2.27	4.72	5.67	2.35	2.62	8.07	8.38
	90° (vertical)	4,44	4.64	2.11	2.76	3.14	4.89	2.64	2.72	6.78	7.62
20cm	180° (horizontal)	4.02	4.30	2.92	2.99	3.88	4.17	3.22	3.30	7.10	7.37
	360° (ring)	4.84	4.16	3.01	3.11	3.01	3.11	4.25	4.45	7.26	7.11
	45° (incline)	5.60	5.71	1.98	2.11	6.45	7.04	3.55	3.85	10.17	10.85
	90° (vertical)	5.25	5.45	2.10	2.19	6.16	6.75	4.01	4.04	10.00	11.77
30cm	180°(horizontal	4.82	4.90	3.25	3.37	5.29	5.42	4.28	4.47	9.57	9.82
	360°(ring)	4.56	4.60	3.34	3.64	3.54	3.65	4.95	5.05	7.49	8.60
	45° (incline)	6.18	6.77	1.46	2.14	8.05	8.71	3.49	3.38	11.54	12.16
	90° (vertical)	6.12	6.48	2.30	2.86	7.75	8.10	3.02	3.72	10.77	11.80
40cm	180° (horizontal)	5.36	6.25	3.25	4.14	5.68	6.48	4.44	4.17	10.12	10.60
	360 (ring)	5.48 °	5.82	3.70	5.02	4.49	4.88	4.15	4.69	8.64	9.53
	FLSD (0.05)	0.20	0.40	0.45	0.56	2.25	2.54	1.82	1.75	2.96	3.01

FLSD = Fisher Least Significant Difference.

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