Effect of Nano Zinc on different Hybrids of Bottle Gourd (*Lagenaria siceraria)*

Abstract: A field experiment was conducted at Vegetable Research Farm, Department of Horticulture, Sam Higginbottom University Institute of Agriculture Sciences conducted to study the effect of Nano Zinc on growth and yield of bottle gourd and their residual effect on succeeding crop. It has laid out by randomized complete block design with 3 replications and 8 hybrids. The factors for the experiment were nano zinc 50ppm and traditional zinc along with the control includes NPK (100:60:40 Kg/ha). The results shown that the highest fruit length (27.67cm), average fruit weight (570.73g), fruit diameter (50.66mm), vine length at last harvest (4.00 m), total no. of nodes at last harvest (44.80), TSS (2.40 ^{0}Brix), vit-c(1.30mg/100mg), color of fruit (Light green) and yield q/ha (135.52), marketable yield (136.52) q/ha was reported. Aforesaid hybrids have highest gross return (410870.63 INR/ha), net return (297870.63 INR/ha) and B: C ratio (2.81). zinc levels (50ppm ha^{1}) as soil application found significant influenced the growth, fruit yield, nutrient content, and yield of bottle gourd. It was recorded that 50ppm zinc ha^{-1} were found best on vine length, fruit girth, number of fruits per plant, seed yield of bottle gourd, zinc content, protein content and growth and yield.

Key words: Bottle gourd, Nano zinc, growth, yield, and quality

INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (2n = 2x = 22) (Mol.) Stand.] is one of the most important vegetable crops gaining importance due to high yielding potential, steady market price throughout the season and export potential. It is good source of protein, carbohydrates, vitamins and minerals and used for different preparations. It has also medicinal properties. It is well demented that the growth and yield of bottle gourd are greatly influenced by wide range of nutrients. Zinc is important micronutrient and is obviously taken up by plants in the ionic form (Zn++). The main function of zinc in plants is a metal activator of enzymes like dehydrogenase, proteinase and peptigenase. It is essential for synthesis of tryptophane, a precursor of indole acetic acid (IAA), which is essential for cell division and other metabolic processes. For oxidation-reduction synthesis of tryptophan for growth yield and quality of the crop. Therefore, it is hypothesized that yield of crops can be enhanced to great extent by application of zinc. With this in view, the present investigation was undertaken to find out the suitable dose in bottle gourd

also known as calabash gourd or white flowered gourd plant, is a member of the Cucurbitaceae family, Cucurbitoideae sub family, and Benincaseae tribe. The family Cucurbitaceae is comprised of 118 genera and 825 species. The genus Lagenaria consists of five other wild species, namely *L. Brevifilora (Benth) Roberty, L. rufa (Gilg) C Jeffrey, L sphaerica E Mey, L. abyssinia (Hook. F.) C Jeffrey and L. guineensis (G Den) C Jeffrey,* of which *L. siceraria* is the most cultivated. Within the species siceraria, two morphologically distinct sub-species of bottle gourd have been recognized *viz*. L. siceraria spp. siceraria and L. siceraria spp. asiatica. The bottle gourd can be easily distinguished from other pumpkin varieties by its white flowers and characteristic fruit, seed and leaf shapes. The fruit is used for variety of purposes, tender fruits used as vegetable and for preparing sweet dishes, rayta and pickles. Bottle gourd is rich source of various essential minerals, iron, protein and full of fibre which is helpful in digestion. The edible portion of bottle gourd contain 96.1% moisture, 3.5 % total soluble solids, 0.12% acidity, 2.5% carbohydrates, 0.2% protein, 0.1% fat, 0.5 % mineral, 0.6% fibre, 44 mg thiamin, 23 mg riboflavin, 0.33 mg niacin and 13 mg ascorbic acid/100 g of edible portion (Deore *et al*., 2008). It is a rich source of potassium, vitamin C, protein, sulphur, fat and phosphorus.

The fruit shape varies from flat to round, oval, oblong and long. Its name "bottle gourd" was probably derived from its bottle shaped variants. The fruit color varies from green to cream or yellow. The flesh is invariably white. In Baster region of Chhattisgarh maximum diversity is found for fruit and seed characters of the bottle gourd (Narayan, 2013). The genetic improvement in bottle gourd depends upon the different selection parameters *viz*. genetic variability, heritability, genetic advance, correlation, path coefficient analysis as well as the genetic divergence of newly introduced to genotypes.

Bottle gourd is a day neutral type plant which can be grown in any time of the year except acute rainy season. Due to its good taste, nutritional status, easier cooking quality, reasonable market price and year-round availability, its demand is increasing day by day. In spite of being in cultivation since ancient times and the presence of the wide germplasm, conscious evaluation and exploitation of germplasm has not been attended to until recently (Harika *et al*., 2012). The extent of genetic variability of existing genotype of a crop plant is an index of its genetic dynamics. Plant breeding revolves around selection which can be effectively practiced only in the presence of variability of desired traits.

The study of biological parameters of the crop is often considered to be a useful step in the study of varietal evalution in Bottle Gourd. Since most of the plant characters of economic importance are polygenic in nature and are highly influenced by environment, it is necessary to work out whether the observed variability is heritable or due to environment. This suggests the imperative need to work out the phenotypic variation into heritable and non-heritable components. Genotypic and phenotypic coefficients of variability help to assess the divergence of the characters. Selection would be more meaningful for the characters which exhibit high variability, heritability along with

high genetic gain. Realizing the economic potential of the crop, there is an urgent need to isolate such breeding lines which have desirable horticultural traits, better quality coupled with high yield Potent.

MATERIALS AND METHODS

The field experiment was conducted during kharif season of 2024 at Vegetable Research Farm, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (UP) during 2024. The field experiment was carried out to study growth parameters like days to germination, vine length(m), no. of node at last harvest, number of male flower, number of female flower, sex ratio, no. of fruit per vine, fruit length(cm), fruit diameter(mm), average fruit weight(g), yield(q/h), marketable yield, TSS (^{0}Brix), (vit-c/100mg), fruit shape, fruit color. The soil of experimental field was sandy loam having available N (149.9 kg/ha), P (27.4 kg/ha), K (190.5 kg/ha) and pH 5.5 to 6.7. There are 3 Replication and 8Hybrids. The Replication comprised 50ppm levels of zinc i.e., (Zno), which were tried in a randomized complete block design and replicated thrice. The recommended dose of N.P.K. @ 80: 40: 60 kg ha^1 was applied uniformly in also the plots. The spacing was kept (2.5*0.5) meters from row to row and plant distance in 7.5 m * 3.0 m plot size. The zinc was applied as per hybrids combination through zinc sulphate as soil application one month before sowing of seeds. Inter cultural operations were done according to package and practices. The data on growth and flowering yield attributing characters (vine length, no. of days taken to first harvest, diameter of fruit, fruit length and fruit per plant, Quality parameter (TSS, vit-color of fruit).

RESULTS AND DISCUSSION

The data revealed that effect of nano zinc on different hybrids influenced the parameters of bottle gourd as presented Table 1. It clearly indicated that significant days to germination, maximum numbers of male and female flower, number of nodes at which male and female appears.

Growth parameters of bottle gourd

Days to germination:

The days to germination among the eight hybrids varied significantly. The earliest germination was recorded at 20 days, while the latest occurred at 22.6 days after sowing. Hybrids SHARDA and BOGHYB-2 germinated faster compared to the others, suggesting higher seed vigor. In contrast, Hybrids BOGHYB-3 and BOGHYB-6 showed delayed germination. These differences highlight the influence of genetic factors on germination behavior. Overall, germination was completed within 20–22.6 days across all hybrids.

Vine Length(m):

A comparative evaluation of vine length among the eight hybrids showed that Hybrid BOGHYB-6 produced the longest vines (4.00m), while Hybrid BOGHYB-2 had the shortest (2.91m). BOGHYB-1 and SHARDA exhibited moderate vine growth. The wide range in vine length reflects the inherent genetic variability among the hybrids and may influence other agronomic traits such as yield and canopy coverage.

Node No. at last Harvest:

A comparative assessment of the number of nodes at last harvest showed that Hybrid BOGHYB-5 had the highest node count (46.07 nodes), while Hybrid BOGHYB-1 had the lowest (41.73 nodes). Hybrids BOGHYB-3 and BOGHYB-6 had moderate node numbers. The broad range in node counts reflects the genetic diversity and varying growth dynamics among the hybrids, which may impact final yield and fruiting potential.

Flowering Parameters of bottle gourd

Number of Male Flower:

The eight hybrids differed notably in their production of male flowers, with numbers ranging from 142.73 to 155.20. Hybrids BOGHYB-6 and BOGHYB-3 produced a higher number of male flowers compared to others, while Hybrid H showed reduced male flower development. Variability in male flower production may be linked to genetic background and could influence fruit set patterns under natural pollination.

Number of Female Flower:

A comparative assessment of female flower numbers revealed that Hybrid BOGHYB-7 produced the highest count (37.27flowers), while Hybrid BOGHYB-5 had the lowest (31.33 flowers). Hybrids BOGHYB-3 and BOGHYB-4 displayed intermediate values. This wide variation in female flower numbers among the hybrids indicates the potential for selecting superior genotypes with higher fruit-bearing capacity.

Sex Ratio

The sex ratio varied considerably among the eight hybrids. Hybrid BOGHYB-7 exhibited the most favorable sex ratio (lower male to female ratio), while Hybrid BOGHYB-1,2,3 showed a higher male dominance. The sex ratio across hybrids ranged from 5:1 to 4:1. Hybrids BOGHYB-7 showed better balance between male and female flowers, indicating good reproductive efficiency. Such variations reflect the genetic influence on sex expression among the hybrids.

Table.1 Evaluation of various bottle gourd hybrids-based on Growth and Flowering Parameters

Symbols	Hybrids	Growth parameters			Flowering parameters		
		Days to germination	vine length (m)	No. of nodes at last harvest	No. of male flowers	No. of female flowers	Sex ratio
H1	BOGHYB-1	21.8	3.81	41.73	149.00	32.07	5.1
H2	BOGHYB-2	21.2	2.91	45.67	142.73	33.13	5.1
H3	BOGHYB-3	22.1	3.76	45.20	154.73	33.67	5.1
H4	BOGHYB-4	21.6	3.72	45.67	153.73	33.40	5.1
H5	BOGHYB-5	21.8	3.06	46.07	152.13	31.33	5.1
H6	BOGHYB-6	22.6	4.00	44.80	155.20	32.33	5.1
H7	BOGHYB-7	21.4	3.34	42.67	153.47	37.27	4.1
H8	SHARDA	20	3.71	43.80	153.00	35.33	5.1
	F test	S	S	S	S	S	
	SE(d)	1.13	0.20	1.70	5.01	1.39	
	C.V.	20.00	6.1	4.68	10.75	5.06	
	CD at 5%level	2.43	0.20	3.64	10.75	2.97	

Yield Parameter of bottle gourd

Number of fruits per vine:

A comparative evaluation of the number of fruits per vine revealed that Hybrid BOGHYB-6 produced the highest number (16.33 fruits), while Hybrid BOGHYB-4 had the lowest (12.33 fruits). Hybrids BOGHYB-1 and BOGHYB-5 showed moderate fruit production. The wide variation in fruit numbers reflects the genetic diversity among the hybrids and their differing yield potentials.

Average fruit weight (g):

The eight hybrids exhibited a wide range in average fruit weight, varying from 570.73 g to 382.65 g. Hybrids BOGHYB-6 and BOGHYB-7 produced heavier fruits, whereas Hybrid BOGHYB-5 recorded lighter fruits. Differences in fruit weight among hybrids may be attributed to genetic makeup, fruit development patterns, and environmental adaptability. This trait plays a key role in determining total yield and commercial acceptance.

Diameter of fruit (mm):

The eight hybrids exhibited considerable variation in fruit diameter, ranging between 50.66 mm and 29.55mm. Hybrids BOGHYB-5 and BOGHYB-6 produced fruits with greater diameter, while Hybrid SHARDA showed relatively smaller-sized fruits. The differences in fruit diameter among hybrids reflect genetic variability and influence both fruit weight and market appeal. Selection for optimum fruit size is important for improving hybrid performance.

Length of Fruit (cm):

Considerable differences in fruit length were observed among the eight hybrids, with measurements ranging from 20.67 cm to 27.67 cm. Hybrid BOGHYB-5 had the longest fruit, while Hybrid BOGHYB-1 produced the shortest. Statistical analysis confirmed that fruit length was significantly influenced by hybrid genetics. Fruit length is an important trait that contributes to overall fruit morphology and marketability.

Yield Per Hectare(q)

A comparative assessment of yield per hectare showed that Hybrid BOGHYB-6 produced the highest yield (39.56 tons/ha), while Hybrid BOGHYB-1 recorded the lowest (23.25 tons/ha). Hybrids BOGHYB-4 and BOGHYB-5 displayed intermediate yields. These differences in yield per hectare reflect the varying potential of the hybrids, with implications for choosing optimal genotypes for high-productivity farming systems.

Marketable Yield(T/ha)

The eight hybrids exhibited notable variation in marketable yield per hectare, ranging from 19 tons/ha to 35 tons/ha. Hybrids BOGHYB-6 and BOGHYB-7 had the highest marketable yield, which was attributed to their superior fruit quality, size, and minimal post-harvest loss. In contrast, Hybrid BOGHYB-1 had a lower marketable yield due to more fruit defects. These findings underscore the importance of selecting hybrids not only for quantity but also for marketable fruit quality.

Table.2: Evaluation of various bottle gourd hybrids based on Yield Parameters

Symbols	Hybrids	Yield Parameters					
		No. of fruit per vine	Average fruit weight(g)	Diameter of fruit(mm)	Length of fruit(cm)	Yield per hectare(q)	Marketable yield(t/h)
H1	BOGHYB-1	15	549.33	44.81	20.67	23.25	19
H2	BOGHYB-2	13	549.33	43.66	20.67	24.32	21
H3	BOGHYB-3	12.67	554.17	44.59	23.67	26.35	23
H4	BOGHYB-4	12.33	549.04	33.02	24.67	28.32	25
H5	BOGHYB-5	14.67	382.65	50.66	27.67	37.23	33
H6	BOGHYB-6	16.33	570.73	50.29	25.33	39.56	35
H7	BOGHYB-7	16.00	567.33	43.27	25.67	35.21	31
H8	SHARDA	14.67	415.77	29.55	21.67	37.25	32

	F test	S	NS	S	NS	S	
	SE(d)	0.57	10.2	2.67	2.92	3.81	
	C.V.	4.93	28.59	7.72	15.10	4.1	
	CD at 5% level	1.23	61.32	5.74	6.28	10.2	

Quality Parameters

TSS(^{0}Brix):

The eight hybrids exhibited significant variation in TSS content, with values ranging from 2.17 to 2.43 ^{0}Brix. Hybrids BOGHYB-1 and BOGHYB-3 showed higher TSS levels, suggesting better fruit sweetness and flavor. In contrast, Hybrid BOGHYB-5 recorded lower TSS, indicating less desirable fruit quality. TSS content is a key factor in determining fruit acceptance by consumers, especially for fresh consumption and processing.

Vitamin-C:

The Vitamin C content varied considerably among the eight hybrids, ranging from 1.10 mg/100g to 1.67 mg/100g. Hybrids SHARDA showed the highest Vitamin C content, indicating superior nutritional value, while Hybrid BOGHYB-4 had lower Vitamin C levels. The differences in Vitamin C content could be attributed to genetic factors, ripening stages, and environmental influences. Vitamin C is a critical antioxidant, and its variation can affect both the health benefits and marketability of the fruits.

Color of fruits:

The color of the fruit varied significantly among the eight hybrids. Hybrid BOGHYB-3 exhibited the most vibrant and appealing color, while Hybrids BOGHYB-1, BOGHYB-4, BOGHYB-5, BOGHYB-6, BOGHYB-7, SHARDA had a Light Green color. The fruit color ranged from (light green) to (dark green) across all hybrids. Hybrids B and F had brighter, more uniform colors, which are often preferred for marketability. These differences in fruit color highlight the genetic diversity influencing visual appeal and consumer preferences.

Shape of fruits:

Fruit shape varied among the hybrids, ranging from round in BOGHYB-1, slender straight long in BOGHYB-2 and long straight in BOGHYB- 1,4,5,6,7,8. The eight hybrids exhibited notable differences in fruit shape, with Hybrid BOGHYB-1 producing the most symmetrical, round fruits, and Hybrid BOGHYB-2 showing slender straight long fruits. Hybrids BOGHYB-3, BOGHYB-4, BOGHYB-5, BOGHYB-6, BOGHYB-7, SHARDA had consistently long straight shapes, which is a desirable trait for fresh fruit markets. Irregular shapes, can result in difficulties with packaging and may affect marketability. Shape is closely linked to consumer perception of quality and fruit handling.

Table.3: Evaluation of various bottle gourd hybrids based on Quality Parameters

Symbols	Hybrids	Quality parameters			
		TSS(^{0}Brix)	Vit-C	Color of fruit	Shape of fruit
H1	BOGHYB-1	2.43	1.20	Light-green	Round
H2	BOGHYB-2	2.23	1.30	Green	Slender straight long
H3	BOGHYB-3	2.43	1.20	Dark green	Long straight
H4	BOGHYB-4	2.33	1.10	Light-green	Long straight
H5	BOGHYB-5	2.17	1.30	Light-green	Long straight
H6	BOGHYB-6	2.40	1.20	Light-green	Long straight
H7	BOGHYB-7	2.23	1.20	Light-green	Long straight
H8	SHARDA	2.37	1.67	Light-green	Long straight
	F test	S	S		

	SE(d)	0.08	0.18		
	C.V.	13.68	17.66		
	CD at 5% level	0.18	0.39		

Table 4: Economics of various bottle gourd hybrids

Hybrids	**Marketable yield(T/ha)**	**Selling price (Rs/t)**	**Cost of cultivation (Rs. /ha)**	**Gross return**	**Net return (Rs. /ha)**	**B:C ratio**
BOGHYB-1	19	12000	1,10000	228,000	118,000	1.07
BOGHYB-2	21	12000	1,10000	252,000	142,000	1.29
BOGHYB-3	23	12000	1,10000	276,000	166,000	1.50
BOGHYB-4	25	12000	1,10000	300,000	190,000	1.72
BOGHYB-5	33	12000	1,10000	396,000	286,000	2.61
BOGHYB-6	35	12000	1,10000	420,000	310,000	2.81
BOGHYB-7	31	12000	1,10000	372,000	262,000	2.38
SHARDA	32	12000	1,10000	384,000	274,000	2.49

CONCLUSION

This study evaluated the performance of various hybrids with respect to fruit yield, quality, and marketable traits. The results revealed significant variation among the hybrids, with BOGHYB-6 outperforming others in terms of total yield (39.56), marketable yield (35), and Vitamin C(2.40mg/100) content. In contrast, SHARDA recorded the lowest values across several traits. These findings suggest that BOGHYB-6 may be a suitable candidate for commercial cultivation due to its superior yield and nutritional profile. The B:C ratio was also highest in the same hybrid with (2.81).

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REFERENCES

1. *Alphonse, M. and Saad, E.M. 2000*. Growing green house cucumber in farm yard and chicken manure media in combination with foliar application of zinc, manganese and boron. Egyptian J. Hort. 27: 315-36.

2. *Balyan, D.S. and Singh, R. 1994.* Uptake studied on nitrogen, phosphorus and zinc in cauliflower. Crop Res. Hissar, 7: 57-58.

3. *Bhupal Raj, G., Patnaik, M.L., Reddy, I.P. and Prasad Rao. 2001*. A Response of Brinjal (Solanum melongena L.) to zinc and iron. Vegetable Sci. 28: 80-81.

4. *Doming, A. and Bertling, I. 2004*. Manganese, zinc and silicon studies of cucumber (Cucumis sativus) using a miniature hydropomic system. Acta Hort. 644: 393-98.

5. *Lindsay, W.L. and Norwell, W.A. 1978*. Development of DPTA-soil test for Zn, Fe, Mn and Cu. Soil Sci. Soc. America J. 42: 421-28.

6. *Madhu-sudhan, P.N. and Shakila, A. 2003*. Effect of zinc on growth, flowering and yield of cucumber (Cucumis sativus L.). South Indian Hort. 51: 195- 98.

7. *Nandini, K. and Potty, N.N. 2000.* Co-factor on simultaneous improvement of yield and quality in bitter gourd (Momordica charantia L.). Madras Agril. J. 87: 721-23.

8. *Patnaik, M.C., Bhupal, G.R. and Reddy, I.P. 2001*. Response of tomato (Lycopersicon esculentum Mll.) to zinc and iron. Vegetable Sci. 28: 78-79.

9. *Phor, S.K., Pandey, U.C. and Verma, U. 1995*. Effect of zinc on the growth and yield of garlic (Allium-sativum). Crop Res. Hisar, 9: 286-91.

10. *Singh, N.P. and Joshi, P. 2002.* Nutritive and medicinal value of cucurbits. A book of vegetable on cucurbits. By ICAR, pp. 7-8.

11. *Bhardwaj, D. R., Singh, A. and Singh, U. (2013*. Genetic variability of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] by multivariate analysis. Published in Proc. Of National Symposium on Abiotic and Biotic Stress management in Vegetable Crops.

Ind. Soc. Veg. Sci. pp. 370.

12. *Celine, V. A., Seeja, G. and Gokulapalan, C. 2011.* Evaluation of snake gourd genotypes for different seasons in the humid tropics. Indian J. Hort., 67(Special Issue): 185-188.

13. *Deore, P. M., Kotecha, P. M. and Pawar, V. D. 2013*. Studies on processing of bottle gourd into juice and powder. Ind. Fd. Pach., 62(6): 116-120.

14. *Gayen, N. and Hossain, M. 2014.* Study of heritability and genetic advance in bottle gourd [Lagenaria siceraria (Mol.) Standl.]. J. of Interacademicia, 10(4): 463- 466.

15. *Harika, M., Gasti, V. D., Shantappa, T., Mulge, R., Shirol, A. M., Mastiholi, A. B*. and

Kulkarni, M. S. 2012. Evaluation of bottle gourd genotypes [Lagenaria siceraria (Mol.) Standl.] for various horticultural characters. Karnataka J. Agric. Sci., **25**(2): (241-244)

16. *Harika, M., Gasti, V., D., Shantappa., Mulge, Shirol, V. B. Mastiholi and Kulkarni, M.* ***S.,*** *2018. Evaluation of bottle gourd genotypes [Lagenaria siceraria* (Mol.) Standl.] for various horticultural characters. Karnataka J. Agric. Sci., 25(2): (241- 244).