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Effect of foliar application of boron, iron and zinc on growth, yield and economics of cucumber grown under naturally ventilated polyhouse condition

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Abstract

A field experiment was conducted to study the effect of foliar application of boron, iron and zinc on growth, yield and economics of cucumber (*Cucumis sativus* L.) grown under naturally ventilated polyhouse condition during *Kharif* season, 2018 in the polyhouse located at College campus, Mata Gujri College, Fatehgarh Sahib, Punjab. The experiment was carried out under Randomized Complete Block Design (RCBD) with three replications and 15 treatments. The important growth and yield parameters encompassed in the study *viz*., node at first flower appear (5.44), days to first flowering (27.90), days to 50 % flowering (38.75), days to first picking (44.19), number of nodes plant^{-1} (55.62), number of leaves plant^{-1} (62.83), leaf area (523.47 cm^2), fruit set (60.26 %), vine length (4.36 m), number of fruits plant^{-1} (27.97), fruit length (18.67 cm), fruit diameter (4.46 cm), fruit girth (12.57 cm), average fruit weight (144.05 g), fruit volume (139.93 cc), fruit yield (4.02 kg plant^{-1} and 67.00 t ha^{-1}), biological yield plant^{-1} (5.74 kg), harvest index (70.03 %) and harvest duration (58.29 days) were significantly superior with the combine foliar application of Zinc 30 ppm + Boron 40 ppm (T_{15}) followed by Zinc 30 ppm + Boron 20 ppm (T_{14}). Net return (Rs. 628660.38) and B: C ratio (3.58) was concerned maximum with the combine application of Zinc 30 ppm + Boron 40 ppm (T_{15}). On the basis of results of present investigation, it can be concluded that foliar application of boron, iron and zinc were found effective in enhancing the growth, yield and economics of cucumber grown under naturally ventilated polyhouse condition.

Keywords: Cucumber, boron, iron, zinc, growth, foliar application, yield and economics

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Introduction

Cucumber (*Cucumis sativus* L.) is popular warm season vegetable, belongs to family cucurbitaceae and having chromosome number 2n=14. It is most consuming vegetable grows throughout the world under tropical and subtropical condition (Lata et al. 2018). It is an ideal summer vegetable crop predominantly grown for its edible tender fruits. The fruits of cucumber is said to have cooling effect, prevent constipation, checks jaundice and indigestion. It contains 96.3 g moisture, 0.4 g protein, 0.3 g minerals (140 mg calcium, 30 mg phosphorus and 0.6 mg iron), 0.4 g fibre, 5.7 g carbohydrates, 0.04 mg riboflavin, 0.4 mg niacin and 4.0 mg vitamin C (Meena et al. 2017). Cucumber is highly valuable vegetable which is likely to be grown under protected conditions for good fruit quality and higher yield (Kumar et al. 2014). Greenhouse cucumber has ability to set fruits parthenocarpically and usually gynoecious which bear fruit at each leaf axil. To improve the growth characteristics of cucumber, proper plant nutrition is essential for successful production of vegetable crops. Integrated supply of micronutrients with macronutrients in adequate amount and suitable proportions is one of the most important factors that control the plant growth and development. Micronutrients are usually required in minute quantities, nevertheless, are vital to the growth of plant (Tripathi et al. 2015). The application of boron is attributed to greater photosynthetic activity resulting, the increased production and accumulation of carbohydrates and also helps in flowering and fruit formation, which helps to improves the growth and yield characteristics of plants (Patidar et al., 2017). Zinc is an essential micronutrients for the functioning of many enzymes as well as the synthesis of tryptophan, a precursor of indole acetic acid (IAA) which is responsible for increasing the production of photosynthates and biomass accumulation thus stimulates growth and yield of plants (Haleema et al. 2018). Iron helps in better absorption of nutrients resulting in efficient physiological and metabolic activities (Vala and Savaliya 2014). Iron is also necessary for the biosynthesis of chlorophyll and cytochrome resulting significant increase in growth and yield (Kazemi 2013).

Material and Methods

The present investigation was conducted during *Kharif* season, 2018 at polyhouse located in the college campus, Mata Gujri College, Fatehgarh Sahib, Punjab to find out the effect of foliar application of different concentrations of boron, iron and zinc on the growth, yield and economics of cucumber (*Cucumis sativus* L.) grown under naturally ventilated polyhouse condition. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and fifteen treatments. The treatments consist of T_1 (Control- water spray), T_2 (Zinc 15 ppm), T_3 (Zinc 30 ppm), T_4 (Iron 60 ppm), T_5 (Iron 80 ppm), T_6 (Boron 20 ppm), T_7 (Boron 40 ppm), T_8 (Zinc 15 ppm + Iron 60 ppm), T_9 (Zinc 15 ppm + Iron 80 ppm), T_{10} (Zinc 30 ppm + Iron 60 ppm), T_{11} (Zinc 30 ppm + Iron 80 ppm), T_{12} (Zinc 15 ppm + Boron 20 ppm), T_{13} (Zinc 15 ppm + Boron 40 ppm), T_{14} (Zinc 30 ppm + Boron 20 ppm), T_{15} (Zinc 30 ppm + Boron 40 ppm). The soil of experimental site was loamy in texture, rich in organic matter and having soil pH (7.8), electrical conductivity (0.54 ds/m), organic carbon (1.11 %), available nitrogen (361.65 kg ha^{-1}), available phosphorus (28.40 kg ha^{-1}) and available potassium (128.48 kg ha^{-1}). The seeds of parthenocarpic cucumber cultivar 'Hilton F_1' were sown on well prepared raised beds on first fortnight of February, 2018. Proper spacing of 60 × 60 cm within plant and between rows maintained to facilitate the various intercultural operations. The recommended dose of fertilizers applied through drip system whereas, micronutrients mixture were applied through foliar application at 15, 30 and 45 days after sowing (DAS). The sources of fertilizers were urea, complex mixture of NPK (19:19:19) and for micronutrients Zinc Sulphate (33% Zn and 15% S), Borax (20%) and Ferrous Sulphate ($FeSO_4.7H_2O$, 19%) were used as foliar spray. Manual harvesting was done at regular intervals of 2-3 days when fruits reached at marketable maturity. The experimental data for various observations were analyzed by fisher's method of analysis of variance (ANOVA) as per outlined by Panse and Sukhatme (1985). The data were analyzed and are presented at the 5% level of significance.

Results and Discussion

Vegetative Characters: In present investigation, all growth attributing characteristics as given in table 1 clearly exhibited significantly influence through different concentrations of micronutrients. The maximum number of nodes $plant^{-1}$(55.62), number of leaves $plant^{-1}$(62.83), leaf area (523.47 cm^2), fruit set (60.26 %), vine length (4.36 m) were recorded with the combine foliar application of Zinc 30 ppm + Boron 40 ppm (T_{15}) which was followed by T_{14} (Zinc 30 ppm + Boron 20 ppm) and the minimum recorded in control. The foliar application of zinc increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately help in improving number of nodes (Dixit et al. 2018). The data presented on vine length of cucumber at final stage of crop growth as influenced by combine foliar application of different micronutrients. The present results indicates that plant

Table 1: Effect of foliar application of boron, iron and zinc on growth of cucumber grown under naturally ventilated polyhouse condition.

Treatments	Node at which first flower appear	Days to first flowering	Days to 50% flowering	Days to first picking	Number of Nodes $plant^{-1}$	Number of leaves $plant^{-1}$	Leaf area (cm^2)	Fruit set (%)	Vine length (m)
T_1 – Control	8.90	37.04	52.97	56.56	40.25	44.47	368.32	45.42	2.78
T_2 - Zinc 15 ppm	8.46	35.41	52.23	55.49	41.13	45.78	396.99	46.48	3.08
T_3 - Zinc 30 ppm	7.79	34.38	48.98	52.81	43.76	49.36	420.66	49.53	3.35
T_4 - Iron 60 ppm	8.77	35.75	52.56	56.52	40.75	45.23	389.11	45.51	2.96
T_5 - Iron 80 ppm	7.92	34.51	49.81	54.78	41.94	48.80	416.85	49.05	3.19
T_6 - Boron 20 ppm	8.21	35.12	50.63	54.89	41.34	48.10	403.60	47.57	3.16
T_7 - Boron 40 ppm	7.62	34.17	47.40	52.28	44.79	51.72	430.15	49.58	3.43
T_8 - Zinc15 ppm +Iron 60 ppm	7.44	34.03	47.36	52.18	45.85	52.21	441.44	49.79	3.45
T_9 - Zinc 15 ppm + Iron 80 ppm	7.37	33.39	46.96	51.27	46.65	52.30	443.40	49.94	3.47
T_{10} - Zinc30 ppm +Iron 60 ppm	6.56	30.50	43.56	47.65	51.70	56.12	485.61	54.09	3.89
T_{11} - Zinc 30 ppm + Iron 80 ppm	6.43	30.10	43.15	47.03	52.19	56.71	489.25	55.11	3.91
T_{12} - Zinc 15ppm +Boron 20 ppm	7.37	33.24	46.94	50.63	46.80	52.39	451.80	50.33	3.50
T_{13} - Zinc 15 ppm + Boron 40 ppm	7.33	33.14	46.89	50.37	47.44	52.40	485.35	50.37	3.52
T_{14} - Zinc 30 ppm + Boron 20 ppm	6.04	29.71	42.07	46.93	52.25	59.10	491.62	56.61	4.10
T_{15} - Zinc 30 ppm + Boron 40 ppm	5.44	27.90	38.75	44.19	55.62	62.83	523.47	60.26	4.36
SE(m) ±	0.19	0.67	1.13	0.93	1.13	1.28	6.66	1.23	0.07
$CD_{0.05}$	0.56	1.93	3.26	2.68	3.26	3.69	19.31	3.57	0.22

height was significantly affected by different concentration of micronutrients and revealed that the maximum vine length (4.36 m) of cucumber was obtained with the combine application of Zinc 30 ppm + Boron 40 ppm (T_{15}), which was followed by T_{14} (Zinc 30 ppm + Boron 20 ppm) with the value of 4.10 m whereas, minimum vine length (2.78 m) was recorded in the T_1 (control). This might due to the enhancement in photosynthesis and other metabolic activity which led to an increase in various plant metabolites responsible for cell division and elongation results improvement in growth characters (Hatwar et al., 2003). Boron linked with the development and differentiation of plant cells and hence helps in elongation of root and shoots (Patil et al. 2008). The increases in number of nodes and leaves plant^{-1} due to increased photosynthetic activity, which is resulted in assimilation of more carbohydrates thereby enhance the cell division and cell elongation (Bommesh et al. 2016).

Increase in leaf area is due to boron application which increases the plasticity of cell wall, followed by hydrolysis of starch to sugars which lower water potential of the cell, resulting in entry of water into the cell thereby causing elongation and rapid cell expansion in leaves. Probable reason for increased the leaf area of plants due to nutrients application which increased the rates of photosynthesis and photosynthates supply nutrients and also accelerate endogenous auxin at growing points (Uikey et al. 2018). The maximum fruit set (60.26 %) was observed with the combine foliar application of Zinc 30 ppm + Boron 40 ppm (T_{15}). This might be due to role of zinc and boron in reducing nutrients competition among fruit lets and hormonal balance and thus preventing fruit drop and increased the fruit set (Malek and Rahim 2011). Boron enhances sugar level and also increases carbohydrates supply for fruit setting (Haque et al. 2011).

Phenological characteristics: The phenological characteristics, node at which first flower appears, days to first flowering, days to 50% flowering and days to first picking were significantly influenced with the foliar application of different micronutrients. The lowest node at which first flower appears (5.44) recorded in T_{15} (Zinc 30 ppm + Boron 20 ppm) that was followed by T_{14} (Zinc 30 ppm + Boron 20 ppm) whereas, highest node at which first flower appears (8.90) observed in control (T_1). This might be due to higher buildup of carbohydrates in plants having forced to initiate flower at lower nodes (Bommesh et al. 2016).

Among the treatments, minimum days to first flowering (27.90 days), 50 % flowering (38.75) and picking (44.19 days) were recorded in T_{15} (Zinc 30 ppm + Boron 40 ppm) which was followed by T_{14} (Zinc 30 ppm + Boron 20 ppm) whereas, maximum days to first flowering (37.04 days), 50% flowering (52.97 days) and picking (56.56 days) were observed in control. It might be because of better absorption of the nutrients which involved in metabolic activity and also activated the hormone which influence the earliness of flowering (Dixit et al. 2018). Another possible reason is that the application of zinc which increased the rates of photosynthesis and photosynthates supply nutrients and also accelerate endogenous auxin during flowering period (Yadav et al. 2001). Zinc is involved in synthesis of Indole acetic acid, metabolism of gibberellic acid. These hormones play an important role in the initiation of flowering, development of reproductive organs and also prevents flower drop in fruit crops.

Yield and related attributes: The data related to yield and its attributing characters are presented in table 2. The assessment of data revealed that the maximum number of fruits plant^{-1} (27.92), fruit length (18.67 cm), fruit diameter (4.46 cm), fruit girth (12.57 cm), average fruit weight (144.05 g) and fruit volume (139.93 cc) were recorded in T_{15} (Zinc 30 ppm + Boron 40 ppm) which was followed by T_{14} (Zinc 30 ppm + Boron 20 ppm). The minimum number of fruits plant^{-1} (18.88), fruit length (15.51 cm), fruit diameter (3.23 cm), fruit girth (9.84 cm), average fruit weight (110.64 g) and fruit volume (107.33 cm) were noticed in control (T_1). The possible reason for maximum number of fruits plant^{-1} in T_{15} was attributed more fruit setting and flower retention due to availability of micronutrients as a foliar feeding (Dixit et al. 2018). Ability to photosynthesis and produce more food increases the generative power, whereby the plant can hold more fruits (Kazemi 2013). Foliar application of Zinc 30 ppm + Boron 20 ppm proved to very effective in producing higher fruit weight, longer and wider fruits attributed due to enhanced photosynthesis, accumulation of carbohydrates and favorable effects on vegetative growth which might have increasing the fruit weight besides increasing the fruit size (Bharati et al. 2018). Another possible reason is due to higher synthesis of carbohydrates and their translocation to the sink, which subsequently helped overall growth of fruits (Kazemi 2013). The application of micronutrients increased the girth of various vegetable crops and cucurbits (Narayanamma et al. 2009).

Among the various treatments, maximum fruit yield plant^{-1} (4.02 kg) and hectare^{-1} (67.00 kg) were recorded in T_{15} (Zinc 30 ppm + Boron 40 ppm) which were followed by T_{14} (Zinc 30 ppm + Boron 20 ppm). Whereas, the minimum fruit yield plant^{-1} (2.08 kg) and

Table 2: Effect of foliar application of boron, iron and zinc on yield and yield attributing characteristics of cucumber grown under naturally ventilated polyhouse condition.

Treatments	Number of fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Fruit girth (cm)	Average fruit weight (g)	Fruit volume (cc)	Fruit yield (kg plant^{-1})	Fruit yield (t ha^{-1})	Biological yield (kg plant^{-1})	Harvest index	Harvest duration (days)
T_1 – Control	18.88	15.51	3.23	9.84	110.64	107.33	2.08	34.66	4.48	46.42	46.59
T_2 - Zinc 15 ppm	19.24	15.78	3.28	10.12	112.97	110.80	2.17	36.16	4.51	48.11	47.84
T_3 - Zinc 30 ppm	20.41	15.97	3.49	10.36	116.95	116.26	2.38	39.66	4.70	50.63	49.76
T_4 - Iron 60 ppm	18.91	15.61	3.25	10.07	110.83	109.03	2.09	34.83	4.50	46.44	47.63
T_5 - Iron 80 ppm	20.05	15.84	3.36	10.33	115.50	114.46	2.31	38.50	4.63	49.89	48.94
T_6 - Boron 20 ppm	19.42	15.82	3.35	10.22	113.34	113.13	2.20	36.66	4.56	48.24	48.34
T_7 - Boron 40 ppm	20.62	16.15	3.56	10.38	118.26	116.80	2.43	40.50	4.86	50.00	50.79
T_8 - Zinc15 ppm +Iron 60 ppm	22.84	16.20	3.69	10.48	122.03	118.47	2.78	46.33	4.89	56.85	50.85
T_9 - Zinc 15 ppm + Iron 80 ppm	22.92	16.24	3.74	10.59	122.93	120.39	2.81	46.83	4.92	57.11	54.39
T_{10} - Zinc30 ppm +Iron 60 ppm	25.13	17.48	4.13	11.69	133.40	130.38	3.35	55.83	5.35	62.61	54.40
T_{11} - Zinc 30 ppm + Iron 80 ppm	25.54	17.50	4.16	11.72	133.77	130.44	3.41	56.83	5.38	63.38	55.42
T_{12} - Zinc 15ppm +Boron 20 ppm	23.05	16.28	3.81	10.75	123.86	121.47	2.85	47.50	4.97	57.34	51.46
T_{13} - Zinc 15 ppm + Boron 40 ppm	23.09	16.32	3.85	10.82	133.27	129.85	3.07	51.16	5.05	60.79	51.54
T_{14} - Zinc 30 ppm + Boron 20 ppm	25.84	17.52	4.19	11.75	135.77	131.48	3.50	58.33	5.40	64.81	55.45
T_{15} - Zinc 30 ppm + Boron 40 ppm	27.92	18.67	4.46	12.57	144.05	139.93	4.02	67.00	5.74	70.03	58.29
SE(m) ±	0.68	0.39	0.08	0.25	2.61	2.39	0.10	1.37	0.10	1.15	0.94
$CD_{0.05}$	1.96	1.12	0.24	0.73	7.55	6.91	0.29	3.98	0.28	3.33	2.73

hectare (34.66 t) were observed in control (T_1). Due to the application of micronutrients the crop traits improved substantially and these traits linearly influenced the fruit yield in positive direction (Rubaye and Atia 2016). Another possible reason for higher yield might be due to micronutrient application which enhanced chlorophyll contents, enzymatic activities and rapid increase in photosynthetic activities, accumulation of photosynthates by vegetative parts and its subsequent translocation to the sink, favorable effect on vegetative growth along with retention of flower and fruits (Karthick et al. 2018). It is evident from pertaining data that the foliar application of different micronutrients significantly influenced the biological yield, harvest index and harvest duration of cucumber plant. The maximum biological yield (5.74 kg), harvest index (70.03 %) and harvest duration (58.29 days) of cucumber plant was obtained with the combine foliar application of Zinc 30 ppm + Boron 40 ppm (T_{15}) which were followed by T_{14} (Zinc 30 ppm + Boron 20 ppm). However, minimum biological yield (4.48 kg), harvest index (46.42%) and harvest duration (46.59 days) were observed in control (T_1). The increase in yield is directly influence of micronutrients may be due to the higher rate of photosynthesis and sugar formation due to enhanced chlorophyll synthesis and enzyme activity which leads to translocation of more photosynthates to growing points which ultimately leads to higher production of dry matter and consequently more yield (Vala and Savaliya 2014).

Table 3: Effect of foliar application of boron, iron and zinc on economics of cucumber grown under naturally ventilated polyhouse condition.

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
T_1 - Control	157519	415920	258401.13	1.64
T_2 - Zinc 15 ppm	171834	433920	262085.81	1.52
T_3 - Zinc 30 ppm	172477	475920	303442.98	1.75
T_4 - Iron 60 ppm	171821	417960	246139.58	1.43
T_5 - Iron 80 ppm	172186	462000	289814.50	1.68
T_6 - Boron 20 ppm	171964	439920	267956.08	1.55
T_7 - Boron 40 ppm	172641	486000	313359.16	1.81
T_8 - Zinc15 ppm +Iron 60 ppm	172654	555960	383305.58	2.22
T_9 - Zinc 15 ppm + Iron 80 ppm	172999	561960	388961.25	2.24
T_{10} - Zinc30 ppm +Iron 60 ppm	173965	669960	495995.43	2.85
T_{11} - Zinc 30 ppm + Iron 80 ppm	174249	681960	507710.67	2.91
T_{12} - Zinc 15ppm +Boron 20 ppm	173040	570000	396959.76	2.29
T_{13} - Zinc 15 ppm + Boron 40 ppm	173105	613920	440814.83	2.54
T_{14} - Zinc 30 ppm + Boron 20 ppm	174338	699960	525622.50	3.01
T_{15} - Zinc 30 ppm + Boron 40 ppm	175340	804000	628660.38	3.58
SE(m) ±	NS	20.27	15.16	0.10
$CD_{0.05}$		58.71	43.91	0.28
Selling price		Rs. 12kg^{-1}		

Economics: Higher money value and less cost of cultivation are desirable characters for getting higher returns. Hence, economics of the treatments was worked out under various concentrations of micronutrients. It is revealed from the data obtained that a significantly highest marketable fruit yield (67.00 t ha^{-1}) and net return (Rs 628660.38) along with benefit cost ratio (3.58) were obtained with the combine foliar application of Zinc 30ppm + Boron 40 ppm (T_{15}). The lowest marketable fruit yield (34.66 t ha^{-1}) and net return (Rs 258401.3) were recorded in control (T_1) whereas, lowest benefit cost ratio (1.43) observed in T_4 (Iron 60ppm). The increase in net return and benefit: cost may be due to increased growth, yield and yield contributing parameters of cucumber. This result corroborates with finding of Patidar et al. (2017) and Sarkar et al. (2017).

Conclusion

On the basis of results summarized above, it can be concluded that out of different treatments, the combine foliar application of Zinc 30 ppm + Boron 40 ppm (T_{15}) gave best results with respect to growth, yield and economics of cucumber. Hence, it is apparent that boron and zinc concentration at different levels had significant positive effect on most of growth, yield and yield attributing characteristics along with economics of cucumber grown under naturally ventilated polyhouse condition.

सारांश

खीरा में वर्ष 2018 के खरीफ ऋतु के दौरान प्राकृतिक रूप से हवादार पालीहाउस के अंदर बोरान, लोहा और जस्ता के छिड़काव खीरे के विकास, उपज, लागत और लाभ पर पड़ने वाले प्रभाव का अध्ययन अनुसंधान कार्य माता गुजरी कालेज, फतेहगढ़, पंजाब में किया गया। यह प्रयोग 15 उपचारों को समाहित कर प्रतिकृति के साथ रेंडमाइज कंप्लीट ब्लॉक डिजाइन के तहत किया गया तथा इस अध्ययन में पौधें की महत्वपूर्ण वृद्धि और उपज कारकों जैसे– पार्श्व गाँठ या प्रथम पुष्पन (5.44), प्रथम पुष्पन के दिन (27.90), 50 प्रतिशत पुष्पन के दिन (38.75), प्रथम तुड़ाई के दिन (44.19), प्रति पौध पार्श्व गाँठों की संख्या (55.62), प्रति पौध पत्तियों की संख्या (62.83), पत्ती का क्षेत्र (523.47 वर्ग मी.), फल धारण (60.26 प्रतिशत), लता की लम्बाई (4.36 मी.), प्रति पौध फलों की संख्या (27.97), फल की लम्बाई (19.67 सेमी.), फल व्यास (4.46 सेमी.), फल घराव (15.57 सेमी.), औसत फल भार (144.05 ग्राम), फल आयतन (139.93 सी.सी.), फल उपज (4.02 किग्रा./पौध एवं 67.00 टन/हे.), प्रति पौध जैविक उपज (5.74 किग्रा.), तुड़ाई गुणांक (70.03 प्रतिशत) एवं तुड़ाई के दिन (58.29 दिन) के मापदंड में जस्ता पी.पी.एम.+ बोरान 20 पी.पी.एम. के संयोजन वाले उपचार का प्रदर्शन अच्छा रहा। जहाँ तक खीरे की शुद्ध प्रतिफल (रु. 628660.38), फसल की लागतः लाभ (3.58) है उससे सबसे ज्यादा लाभ जस्ता 30 पी.पी.एम. + बोरान 40 पी.पी.एम. के संयोजन का छिड़काव किया गया था। इसमें पाया गया कि वर्तमान जाँच के परिणामों के आधार पर, यह निष्कर्ष निकाला जा सकता है कि प्राकृतिक रूप से हवादार पालीहाउस स्थिति के तहत उगाए गए खीरे की वृद्धि, उपज, लागत और बचत को बढ़ाने के लिये बोरान, लोहा और जस्ता के पर्णीय प्रयोग प्रभावी पाए गये।

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