

## Response of Nitrogen, Sulfur and Foliar Application of Zinc on Growth, Yield and Economics of Greengram (*Vigna radiata* L.)

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Received 27 October 2016; Accepted 30 November 2016; Published online 19 December 2016

**Abstract** The experiment consisted of two levels of nitrogen viz., 15, 25 kg ha<sup>-1</sup> and sulfur three levels viz., 0, 20, 40 kg ha<sup>-1</sup> and two levels of 0.1% zinc spray viz., at pre-flowering and pod initiation stage with 13 treatments replicated thrice in a randomized block design. Application of 25 kg N ha<sup>-1</sup> + 40 kg S ha<sup>-1</sup> + 0.1% zinc (Pre flowering and Pod initiation) significantly increased growth and yield parameters viz., Maximum plant height (65.30 cm), number of branches<sup>-1</sup> (3.47), number of nodules plant<sup>-1</sup> (46.40), number of pods plant<sup>-1</sup> (30.33), seed yield (8.89 q ha<sup>-1</sup>), stover yield (27.10 q ha<sup>-1</sup>) while number of seeds pod<sup>-1</sup>, test weight

were non-significant. Similarly, application of 25 kg N ha<sup>-1</sup> + 40 kg S ha<sup>-1</sup> 0.1% zinc (Pre flowering and Pod initiation) recorded highest gross return (Rs 44092.0 ha<sup>-1</sup>), net return (Rs 24739.0 ha<sup>-1</sup>) and B:C ratio (2.30) while lowest gross return (Rs 29083.0 ha<sup>-1</sup>), net return (Rs 11109.0 ha<sup>-1</sup>) and B:C ratio (1.61) was obtained in treatment T<sub>1</sub> (control) respectively.

**Keywords** DAC and FW, DES, Greengram, IYP, Zinc.

### Introduction

India is the largest producer and consumer of pulse contributes 25% of global production, 27% of world consumption and importer 14% of pulses in the world. The area under pulse has increased from 19 m ha<sup>-1</sup> in 1950-51 to 25 m ha<sup>-1</sup> in 2013-14, indicating an increase of 31 percent whereas production of pulse during the same period has increased from 8.41 million ha<sup>-1</sup> to 19.27 million ha<sup>-1</sup> an increase of over 100% [1]. In 2014-15 17.20 million tones and estimate production for 2015-16 about 18.32 million tons [2]. Greengram is scientifically known as *Vigna radiata* (L.) and commonly known as mung in India. Greengram seeds are highly nutritious with protein (23–24%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. Nitrogen enhances the uptake of other nutrients and increasing nitrogen content in the crop which increases protein content of greengram. Sulfur plays an important role in improving yield and quality of pulses. S is also known to promote nodulation in

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**Table 1.** Effect of nitrogen, sulfur and zinc on growth of greengram.

Treatments	Plant height (cm)	Plant height	No. of branches	No. of branches	No. of nodules plant <sup>-1</sup>	No. of nodules plant <sup>-1</sup>	Dry weight (g plant <sup>-1</sup> )	Dry weight (g plant <sup>-1</sup> )
T <sub>1</sub> Control	48.33	58.63	0.93	1.93	39.50	22.83	6.89	12.88
T <sub>2</sub> 15 kg N ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	49.57	59.73	1.20	2.20	40.50	21.83	7.00	12.66
T <sub>3</sub> 15 kg N ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	49.67	60.60	1.07	2.07	41.23	21.33	7.09	12.75
T <sub>4</sub> 15 kg ha <sup>-1</sup> + 20 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	51.06	61.20	1.20	2.20	41.00	21.33	7.14	12.99
T <sub>5</sub> 15 kg N ha <sup>-1</sup> + 20 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub>	51.56	61.70	1.20	2.20	41.50	22.50	7.14	12.80
T <sub>6</sub> 15 kg N ha <sup>-1</sup> + 40 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	51.83	61.93	1.53	2.53	42.67	22.67	7.13	13.13
T <sub>7</sub> 15 kg N ha <sup>-1</sup> + 40 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub>	50.90	62.90	1.67	2.60	45.07	25.07	7.28	13.28
T <sub>8</sub> 25 kg N ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	52.00	62.91	1.60	2.63	42.42	22.50	7.32	12.68
T <sub>9</sub> 25 kg N ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	52.26	62.86	1.80	2.80	42.33	22.33	7.33	12.33
T <sub>10</sub> 25 kg N ha <sup>-1</sup> + 20 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	52.81	63.83	1.82	2.87	43.27	22.93	7.47	12.79
T <sub>11</sub> 25 kg N ha <sup>-1</sup> + 20 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub>	53.16	64.36	2.00	3.00	44.17	23.17	7.53	13.20
T <sub>12</sub> 25 kg N ha <sup>-1</sup> + 40 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	53.80	64.80	2.13	3.20	44.67	23.00	7.61	13.30
T <sub>12</sub> 25 kg N ha <sup>-1</sup> + 40 kg S ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub>	54.63	65.30	2.50	3.47	46.40	25.83	7.76	13.41
CD at 5%	1.20	1.36	0.17	0.17	1.61	3.62	0.17	0.81
SEd	0.43	0.49	0.08	0.08	0.78	1.76	0.08	0.39

legumes thereby enhancing the N fixation. It is a constituent of free amino acid such as methionine, cysteine, and plays a vital role in protein synthesis [3]. Zinc is involved in auxin metabolism like, tryptophan synthesis metabolism, protein synthesis, formation of nucleic acid and helps in utilization of nitrogen as well as phosphorus by plants. It also promotes nodulation and nitrogen fixation in leguminous crops [4]. Foliar application of zinc greatly affects plant growth and crop production. Significant positive effect of zinc on seed and straw yield of Mungbean as well as crude protein % found in the seeds [5].

### Materials and Methods

A field experiment was conducted during rainy season 2015 at the Crop Research Farm, Department of Agronomy, Allahabad School of Agricultural, Sam

Higginbottom Institute of Agriculture Technology and Sciences, Allahabad. The soil was sandy loam in texture having a pH (7.3), EC (0.26), organic carbon (0.40%), available N (250 kg ha<sup>-1</sup>), P (13.50 kg ha<sup>-1</sup>), K (313 kg ha<sup>-1</sup>), S (13.93 kg ha<sup>-1</sup>), and Zn (0.50 ppm) during the experimental year. The experiment was laid down in randomized block design (RBD) with three levels of S (0, 20 and 40 kg S ha<sup>-1</sup>) and N (15 and 25 kg N ha<sup>-1</sup>) and two levels of 0.1% zinc spray viz., at pre-flowering and both at pre-flowering and pod initiation stage with 13 treatments and 3 replications. The summer mungbean variety Samrat was sown in rows, 30 cm apart using 20 kg seeds ha<sup>-1</sup> on 10 June in 2015. The crop was thinned after complete germination to maintain a plant to plant spacing of 10 cm apart. A common dose of N, phosphorus and potassium at 40:30 kg ha<sup>-1</sup> was applied through ammonium phosphate and murate of potash, respectively. The treatment consisted of T<sub>1</sub>- (control), T<sub>2</sub>- 15 kg N ha<sup>-1</sup> +

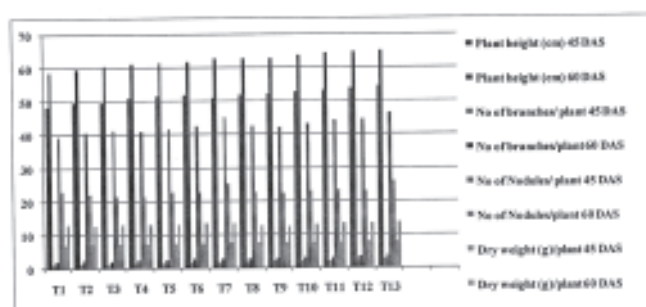


Fig 1: Effect of nitrogen, sulphur and zinc on growth of greengram

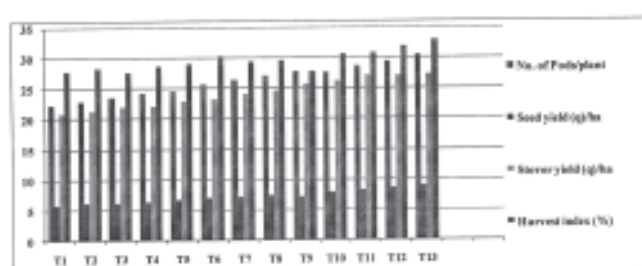


Fig 2: Effect of nitrogen, sulphur and zinc on yield of greengram

Fig. 1. Effect of nitrogen, sulfur and zinc on growth of greengram, Fig. 2. Effect of nitrogen, sulfur and zinc on yield of greengram.

0.1%  $ZnSO_4$  (Pre flowering),  $T_3$  - 15 kg N  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering and Pod initiation),  $T_4$  - 15 kg N  $ha^{-1}$  + 20 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering),  $T_5$  - 15 kg N  $ha^{-1}$  + 20 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering and Pod initiation),  $T_6$  - 15 kg N  $ha^{-1}$  + 40 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering),  $T_7$  - 15 kg N  $ha^{-1}$  + 40 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering and Pod initiation),  $T_8$  - 25 kg N  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering),  $T_9$  - 25 kg N  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering and Pod initiation),  $T_{10}$  - 25 kg N  $ha^{-1}$  + 20 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering),  $T_{11}$  - 25 kg N  $ha^{-1}$  + 20 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering and Pod initiation),  $T_{12}$  - 25 kg N  $ha^{-1}$  + 40 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering),  $T_{13}$  - 25 kg N  $ha^{-1}$  + 40 kg S  $ha^{-1}$  + 0.1%  $ZnSO_4$  (Pre flowering and Pod initiation). N, S and zinc were applied through urea, gypsum and zinc silfate as per treatment and incorporated in soil followed by irrigation to ensure microbial activities to hasten oxidation of S. To reduce the weed infestation, one hand weeding was carried out at 25 DAS. A total of 3 irrigations were applied at critical stages of the crop.

## Results and Discussion

### Plant height (cm)

Maximum plant height (54.63 cm) and (65.30 cm) was recorded in treatment  $T_{13}$  at 45 DAS and 60 DAS respectively as compared to  $T_1$  control (Table 1) and (Fig. 1). This could be attributed to combined effect of nitrogen, sulfur and foliar application of zinc. The application of sulfur increased chlorophyll formation which enhances the photosynthesis resulting an increase in plant growth attributes and nitrogen and zinc increases the metabolism of growing plants which favorable response of zinc on plant height was also recorded by Sharma and Sharma [6].

### Number of branches plant<sup>-1</sup>

Maximum number of branches plant<sup>-1</sup> (2.50) and (3.47) was recorded in treatment  $T_{13}$  while, minimum number of branches plant<sup>-1</sup> (0.93) and (1.93) was recorded in

**Table 2.** Effect of nitrogen, sulfur and zinc on yield of greengram.

Treatments	No. of pod plant <sup>-1</sup>	Seed yield (q ha)	Stover yield (q ha)	Harvest index %
T <sub>1</sub> Control	22.23	5.77	20.78	27.77
T <sub>2</sub> 15 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	22.77	5.98	21.2	28.23
T <sub>3</sub> 15 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	23.47	6.02	21.82	27.60
T <sub>4</sub> 15 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	24.20	6.29	22.00	28.58
T <sub>5</sub> 15 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	24.60	6.57	22.78	28.88
T <sub>6</sub> 15 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> +0.1% ZnSO <sub>4</sub> (Pre flowering)	25.57	6.98	23.09	30.13
T <sub>7</sub> 15 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	26.23	7.02	23.98	29.28
T <sub>8</sub> 25 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	27.03	7.22	24.5	29.49
T <sub>9</sub> 15 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	27.77	7.1	25.55	27.80
T <sub>10</sub> 25 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	27.47	7.9	26.03	30.51
T <sub>11</sub> 25 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	28.63	8.12	26.99	30.71
T <sub>12</sub> 25 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	29.40	8.57	26.99	31.74
T <sub>13</sub> 25 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	30.33	8.89	27.10	32.82
CD at 5%	1.24	3.17	14.81	1.62
SEd (±)	0.60	1.54	7.23	0.79

treatment T<sub>1</sub> (control) at 45 DAS and 60 DAS respectively (Table 1) and (Fig. 1). The probable reason for increasing branches plant<sup>-1</sup> may be due to beneficial effect of nitrogen, sulfur, zinc, Patel et al. [2] reported that application of 40 kg sulfur ha<sup>-1</sup> recorded significantly maximum number of branches plant<sup>-1</sup>, number of nodules plant<sup>-1</sup>, seed yield and protein content.

#### Number of nodules plant<sup>-1</sup>

Maximum number of nodules plant<sup>-1</sup> (46.40) and (25.83) were recorded in treatment T<sub>13</sub> while minimum number of nodules plant<sup>-1</sup> was recorded in treatment T<sub>1</sub> (control) at 45 DAS and 60 DAS respectively. However treatment T<sub>11</sub> was found to be statistically at par to treatment T<sub>13</sub> (Table 1) and (Fig. 1). Probable reason for increasing nodules plant<sup>-1</sup> may be due to beneficial effect of nitrogen and sulfur. This could be attributed to sulfur is a constituent of three essential amino acids (cysteine, cystine and methionine). Sulfur is a constituent of ferredoxin-containing nitrogenase, which takes part in the biological nitrogen fixation resulting the highest number of nodules plant<sup>-1</sup> Khan and Ved [7].

#### Plant dry weight (g plant<sup>-1</sup>)

The observations regarding plant dry weight are being presented in (Table 1) and (Fig. 1) observed significant difference between the treatments at different intervals. Maximum plant dry weight (7.76 g) and (13.41 g) were recorded in treatment T<sub>11</sub>, while minimum plant dry weight (6.89 g) and (12.33 g) were recorded in T<sub>1</sub> and T<sub>9</sub> at 45 and 60 DAS respectively. Probable reason for dry matter accumulation plant<sup>-1</sup> may be due to beneficial effect of nitrogen, sulfur and zinc. However the essential role of zinc has been established as a component of several enzymes concerned with carbohydrate and nitrogen metabolism, in addition to its involvement directly or indirectly in regulating the various physiological processes of plants. Similar results were reported by Khatkar et al. [8]. Successive increase in S levels up to 20 kg ha<sup>-1</sup> significantly increased plant height, number of leaves plant<sup>-1</sup> and number of nodules plant<sup>-1</sup>, plant dry weight, seed and straw yield. Roy et al. [9] reported foliar and basal application of zinc performed better than higher dose the lowest dry weight of shoot was recorded in control.

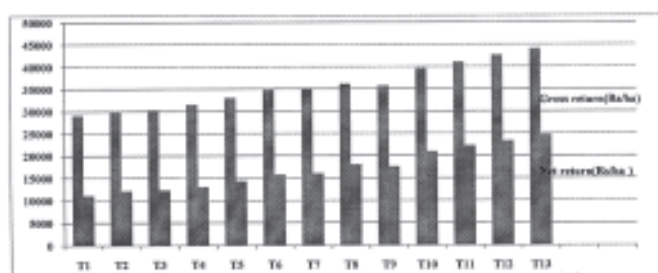


Fig. 3. Effect of nitrogen, sulfur and zinc on economics of greengram.

#### Yield and yield attributes

Application of 25 kg N ha<sup>-1</sup> 40 kg S ha<sup>-1</sup> + 0.1% zinc (Pre flowering and Pod initiation) has significant influence on yield and yield attributes viz number of pods plant<sup>-1</sup>, seed yield, stover yield and harvest index of greengram over control. Maximum number of pods plant<sup>-1</sup> (30.33), seed yield q ha<sup>-1</sup> (8.89), stover yield q ha<sup>-1</sup> (27.10) and harvest index (32.82%) were recorded in treatment T<sub>13</sub>, while minimum number of pods plant<sup>-1</sup> (22.23), seed yield q ha<sup>-1</sup> (5.77), stover yield q ha<sup>-1</sup> (20.78) and harvest index (27.77%) were recorded in treatment T<sub>1</sub> (control). However, treatment T<sub>11</sub> was found to be statistically at par to treatment T<sub>13</sub> with respect to number of pods plant, seed yield,

stover yield and harvest index respectively (Table 2) and (Fig. 2). The probable reason may be due to beneficial effect of nitrogen, Sulfur and Zinc. Similar findings were also reported by Dhanushkodi et al. [10] the factor which are directly responsible for ultimate grain production pods/plant, were increased almost significantly due sulfur ha<sup>-1</sup> + 0.1% ZnSO<sub>4</sub> (Pre flowering and Pod initiation). Ram and Katiyan [3] the highest seed yield (13.69 and 14.40 q ha<sup>-1</sup>) was observed in combination with 40 kg S ha<sup>-1</sup> and 10 kg Zn ha<sup>-1</sup> which was significantly superior over rest of the combinations. Similarly Rathi et al. [11] number of pods, 100 grain weight and harvest index also increased to great extent by the application of *Rhizobium* along with the sulfur and micronutrients. Closer results are confined with Marko et al. [12].

Table 3. Effect of nitrogen, sulfur and zinc on economics of greengram.

Treatments	Gross return (Rs ha <sup>-1</sup> )	Net return (Rs ha <sup>-1</sup> )	B:C ratio
T <sub>1</sub> Control	29083	11109	1.61
T <sub>2</sub> 15 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	30112	12134	1.67
T <sub>3</sub> 15 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	30386	12328	1.68
T <sub>4</sub> 15 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	31605	13057	1.70
T <sub>5</sub> 15 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	33005	14377	1.77
T <sub>6</sub> 15 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> +0.1% ZnSO <sub>4</sub> (Pre flowering)	34882	15761	1.82
T <sub>7</sub> 15 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	35201	16000	1.83
T <sub>8</sub> 25 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	36201	18071	1.99
T <sub>9</sub> 25 kg nitrogen ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	35800	17590	1.96
T <sub>10</sub> 25 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	39648	20948	2.12
T <sub>11</sub> 25 kg nitrogen ha <sup>-1</sup> + 20 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	41060	22280	2.18
T <sub>12</sub> 25 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering)	42614	23341	2.21
T <sub>13</sub> 25 kg nitrogen ha <sup>-1</sup> + 40 kg sulfur ha <sup>-1</sup> + 0.1% ZnSO <sub>4</sub> (Pre flowering & Pod initiation)	44092	24739	2.30

## Economics

Similarly, application of 25 kg N ha<sup>-1</sup> + 40 kg S ha<sup>-1</sup> + 0.1% zinc (Pre flowering and Pod initiation) recorded highest gross return (Rs 44092.0 ha<sup>-1</sup>), net return (Rs 24739.0 ha<sup>-1</sup>) and B:C ratio (2.30) while lowest gross return (Rs 29083.0 ha<sup>-1</sup>), net return (Rs 11109.0 ha<sup>-1</sup>) and B:C ratio (1.61) was obtained in treatment T<sub>1</sub> (control). The increase in gross return with application of nitrogen, sulfur and zinc was due to increase in grain and stover yield of greengram (Table 3) and (Fig. 3). Closer findings were reported by Patel et al. [4] and Marko et al. [12].

## Conclusion

It may be concluded that among the different treatments 25 kg N ha<sup>-1</sup> 40 kg S ha<sup>-1</sup> + 0.1% zinc (pre flowering and pod initiation) was found to be the best for obtaining highest seed yield, stover yield and benefit cost ratio in greengram. Since the findings are based on the research done in one season it may be repeated for confirmation.

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