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# Balanced fertilization of greengram (*Vigna radiata* var *radiata*) cultivars on a multi-nutrient deficient Typic Ustochrept soil

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ABSTRACT

A field experiment was conducted during 2001–2002 on typic Ustochrepts of Kanpur (Uttar Pradesh), to evaluate the performance of greengram [*Vigna radiata* var *radiata* (L.) R. Wilczek] cultivars to balanced fertilizer application. One level of nitrogen (20 kg/ha), 3 levels of phosphorus (8.75, 17.5 and 26.2 kg/ha), 4 levels of sulphur (20, 40 and 60 kg/ha), 1 level each of potassium (50 kg/ha), zinc (5 kg/ha) and boron (1 kg/ha) were superimposed one over the other in randomized block design with 3 replications. There was 2-fold increase in biomass with P application and 2.5-fold increase with S application. 'Samrat' and 'NM 1' responded to applied zinc, while 'PDM 11' and 'PDM 54' did not show any response. Higher fertility levels (26.2 kg P/ha and 40 kg S/ha) were not effective in increasing the nodulation or the yield levels. The benefit that greengram can derive from nutrient application may be limited to the level of their deficiency corrections in the soil. In spite of significant relationship observed between nodulation and seed yield (r = 0.688), this was not in commensurate with the extent of differences observed in seed yield (1 667 to 2 154 kg/ha).

**Key words:** Balanced fertilization, Greengram, Biomass, Nodulation, Yield, Multi-nutrient deficient soil

Greengram [*Vigna radiata* var *radiata* (L.) R. Wilczek] is photo-insensitive and its cropping duration varies with cultivars and climate. Because of this character, the crop can be fitted well into any cropping system and adjust the sowing period in the rainy season according to onset of monsoon but can also be grown as a break crop between wheat (*Triticum aestivum* L. emend. Fiori & Paol.) and rice (*Oryza sativa* L.) in summer in Indogangetic plain under intensive cropping. One of the main reasons for the low yield of greengram is that farmers generally do not apply the recommended levels of fertilizers to the crop (Ganeshamurthy *et al.* 2002). In addition, due to multi-nutrient deficiency application of a small dose of 1 or 2 nutrients, particularly N may not benefit the farmers to the desired level. To realize the yield potential of the crop, nutrients must be applied in proper quantity and balanced proportion.

Balanced fertilization would essentially mean rational use of fertilizers for supply of nutrients to the crop in such a manner that would ensure among others maintaining soil productivity and sustain high yield commensurate with the biological potential of the crop variety under the unique soil, climate and agroecological set up (Goswami 1998, Swaroop and Ganeshamurthy 1998). Hence this study was conducted using the most popular cultivars of greengram to determine their potential and the level of balanced nutrients required for realizing their yield potential.

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## MATERIALS AND METHODS

### *Analysis of soil*

The experiment was conducted between 2001 (site I) and 2002 (site II) on Typic Ustochrept at the new Research Farm of the Indian Institute of Pulses Research, Kanpur. The initial soil samples were analyzed for various physico-chemical properties following standard methods. Mineralisable nitrogen (N) was estimated by the alkaline permanganate method (Subbiah and Asija 1956). Phosphorus (P) was extracted with sodium bicarbonate (Olsen *et al.* 1954) and potassium (K) by 1 M neutral ammonium acetate (Hanway and Heidel 1952). Sulphur was extracted with 0.01 M $CaCl_2$ (Willams and Steinbergs 1959). Available Zn was extracted with DTPA and estimated using atomic absorption spectrophotometer (Lindsay and Norvell, 1978) and B was estimated with 0.05 M mannitol following the method of Cartwright *et al.* (1983). The soil of site I was a Typic Ustochrept loamy sand having *p*H 8.1, organic C 0.37%, available N 123 kg/ha, P 7.1 kg/ha, K 68 kg/ha, S 17 kg/ha, Zn 0.52 ppm and B 0.36 ppm. The soil of site II was also a Typic Ustochrept loamy sand having 8.2 *p*H, organic C 0.34%, available N 144 kg/ha, P 7.9 kg/ha, K 79 kg/ha, S 21 kg/ha, Zn 0.47 ppm and B 0.31 ppm.

*Experimental design*

In a set of 10 treatment plots, 4 leading cultivars of greengram, viz 'PDM 1', 'PDM 54', 'Narendra Mung 1' ('NM 1') and 'Samrat' were sown with a row to row spacing of 30 cm and 8 cm plant-to-plant and 3 cm depth of sowing in the third week of June at site I in 2001 and site II in 2002. The treatment details are $T_1$, 20 kg N/ha; $T_2$, $T_1$+ 8.75 kg P/ha; $T_3$, $T_1$+ 17.5 kg P/ha; $T_4$, $T_1$ + 26.2 kg P/ha; $T_5$, $T_4$+ 20 kg S/ha; $T_6$, $T_4$ + 40 kg S/ha; $T_7$, $T_4$+ 60 kg S/ha; $T_8$, $T_7$ + 50 kg K/ha; $T_9$, $T_8$+ 5 kg Zn/ha; and $T_{10}$, $T_9$+1 kg B/ha. Each treatment was performed in triplicate in a randomized block design (plot size 20 m × 10 m). Fertilizers were broadcast and mixed well in the top 15 cm of soil using a rotary hoe. The crop was grown as a rainfed crop, since the 800 mm rainfall received in this area during the monsoon season is sufficient for its normal cultivation. Before crop emerged, weeds were controlled using herbicide (pendimethlin) sprays. No pests were observed in the crop in both the years. Every year at 50% flowering, 5 random plants were carefully uprooted from each plot and washed gently and the nodules were separated from the roots. The total number of nodules was counted and then using a scalpel, the nodules were cut open. The nodules with the pink colour of leghaemoglobin were considered active nodules. The nodules were then bulked, dried in an oven at 75°C and weighed for dry weight of nodules. At day 45 after sowing, 1 m² area was harvested from each plot and the material was dried in an oven and weighed for biomass yield. Statistical analyses were performed.

## RESULTS AND DISCUSSION

The soils of the experimental sites were well-drained loamy sands, alkaline in reaction and low in organic carbon. Both the soils were low in available N, P, K, S, Zn and B. These soils are under cultivation of pulses for the last 2 decades.

*Nodulation*

'Samrat' gave maximum nodules (89.6/5 plants) followed by 'PDM 54' (86.8), 'PDM 11' (79.6) and 'NM 1' (72.5) (Fig 1). Application of nutrients to greengram showed significant effect on production of nodules. 'Samrat' recorded maximum nodulation (61 nodules/5 plants) in control ($N_{20}$) followed by 'PDM 54', 'PDM 11' and least in 'NM 1' (Table 1). An increase in nodulation was recorded up to 17.5 kg P/ha in 'PDM 54' and 'PDM 11'. Application of 17.5 kg P/ha increased the nodules from 61 to 86 in 'Samrat' and 48 to 67/5 plants in 'NM 1'. But in 'PDM 54' and 'PDM 11' these increased from 59 to 87 and 57 to 79, respectively, at 26.2 kg P/ha. Kumar *et al.* (2002) also reported increased nodulation with increase in level of applied P. Irrespective of the cultivars there was significant increase in number of nodules to S application at 20 kg S/ha. At applied S beyond 20 kg/ha the mean nodule production reached a plateau and did not increase further. Ganeshamurthy and Reddy (2000) also did not find any increase in nodulation in soybean grown on Vertisols beyond 20 kg S/ha. Though statistically it was not possible to work out the interaction, it appeared that there was no interaction between applied P and S on nodulation in greengram. Application of potassium did not influence nodulation. This is probably because these soils are well supplied with 1 N boiling nitric acid extractable K (Srinivasarao *et al.* 2002) and the real effect of K on nodulation could not be ascertained. Although the soil was deficient in boron, its application did not enhance nodulation in greengram. But application of Zn increased the nodulation from 81 to 86 in 'NM 1' and 98 to 104 in 'Samrat'.

Active nodules were separated by its pink colouration due to leghaemoglobin. The mean treatment effect on active nodule production in the 4 cultivars is presented in Fig 1. By and large active nodule production followed the similar trends of total nodule production. However, at higher levels of P and S the number of active nodules did not alter (Table 2). Olayinka *et al.*(1998) and Ganeshamurthy and Reddy(2000) also observed that higher levels of applied nutrients depress the

Table 1 Effect of balanced fertilization on total nodules, number of active nodules and dry weight of nodules (5 plants) in greengram cultivars

| Treatment | 'PDM 11' | | | 'PDM 54' | | | 'Narendra Mung 1' | | | 'Samrat' | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total nodule | Active nodule | Dry weight of nodule | Total nodule | Active nodule | Dry weight of nodule | Total nodule | Active nodule | Dry weight of nodule | Total nodule | Active nodule | Dry weight of nodule |
| $T_1$, $N_{20}$ | 57 | 33 | 0.96 | 59 | 34 | 0.99 | 48 | 27 | 0.81 | 61 | 33 | 0.96 |
| $T_2$, $T_1$+$P_{8.7}$ | 65 | 40 | 1.08 | 68 | 42 | 1.14 | 51 | 31 | 0.87 | 79 | 49 | 1.35 |
| $T_3$, $T_1$+$P_{17.5}$ | 74 | 48 | 1.23 | 79 | 47 | 1.35 | 67 | 41 | 1.14 | 86 | 53 | 1.47 |
| $T_4$, $T_1$+$P_{26.2}$ | 79 | 46 | 1.32 | 87 | 49 | 1.47 | 67 | 36 | 1.14 | 84 | 48 | 1.41 |
| $T_5$, $T_4$+$S_{20}$ | 87 | 57 | 1.47 | 95 | 58 | 1.62 | 79 | 49 | 1.35 | 108 | 58 | 1.62 |
| $T_6$, $T_4$+$S_{40}$ | 85 | 54 | 1.41 | 94 | 54 | 1.59 | 82 | 46 | 1.38 | 93 | 51 | 1.56 |
| $T_7$, $T_4$+$S_{60}$ | 85 | 52 | 1.44 | 96 | 52 | 1.62 | 80 | 45 | 1.35 | 95 | 53 | 1.62 |
| $T_8$, $T_7$+$K_{60}$ | 84 | 54 | 1.41 | 95 | 58 | 1.62 | 81 | 50 | 1.38 | 98 | 58 | 1.65 |
| $T_9$, $T_8$+$Zn_5$ | 90 | 69 | 1.53 | 98 | 70 | 1.68 | 86 | 63 | 1.44 | 104 | 75 | 1.77 |
| $T_{10}$, $T_9$ + $B_1$ | 90 | 64 | 1.50 | 97 | 67 | 1.65 | 84 | 60 | 1.41 | 101 | 73 | 1.71 |
| LSD ($P$ = 0.05) | 5.1 | 4.2 | 0.09 | 6.2 | 5.6 | 0.06 | 6.8 | 4.3 | 0.06 | 5.9 | 4.8 | 0.09 |

Table 2 Effect of balanced fertilization on seed yield (kg/ha) in greengram cultivars

| Treatment | 'PDM 11' | | | 'PDM 54' | | | 'Narendra Mung 1' | | | 'Samrat' | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | Mean | 2001 | 2002 | Mean | 2001 | 2002 | Mean | 2001 | 2002 | Mean |
| $T_1$, $N_{8.7}$ | 559 | 648 | 604 | 604 | 660 | 632 | 763 | 935 | 849 | 712 | 816 | 764 |
| $T_2$, $T_1+P_{17.2}$ | 971 | 1 101 | 1 036 | 917 | 1 019 | 968 | 1 159 | 1 314 | 1 236 | 1 108 | 1 210 | 1 159 |
| $T_3$, $T_1+P_{26.2}$ | 1 314 | 1 426 | 1 370 | 1 236 | 1 346 | 1 291 | 1 472 | 1 570 | 1 521 | 1 395 | 1 481 | 1 438 |
| $T_4$, $T_1+P_{60}$ | 1 352 | 1 450 | 1 401 | 1 349 | 1 417 | 1 383 | 1 589 | 1 679 | 1 634 | 1 485 | 1 549 | 1 517 |
| $T_5$, $T_4+S_{20}$ | 1 512 | 1 606 | 1 559 | 1 509 | 1 650 | 1 579 | 1 793 | 1 925 | 1 859 | 1 765 | 1 845 | 1 805 |
| $T_6$, $T_4+S_{40}$ | 1 530 | 1 618 | 1 574 | 1 498 | 1 594 | 1 546 | 1 888 | 1 984 | 1 936 | 1 821 | 1 945 | 1 883 |
| $T_7$, $T_4+S_{60}$ | 1 523 | 1 614 | 1 568 | 1 502 | 1 578 | 1 540 | 1 894 | 1 946 | 1 920 | 1 826 | 1 922 | 1 874 |
| $T_8$, $T_7+K_{60}$ | 1 574 | 1 586 | 1 570 | 1 544 | 1 670 | 1 607 | 1 906 | 2 034 | 1 970 | 1 818 | 1 914 | 1 866 |
| $T_9$, $T_8+Zn_5$ | 1 580 | 1 638 | 1 609 | 1 618 | 1 779 | 1 698 | 1 989 | 2 201 | 2 095 | 1 966 | 2 048 | 2 007 |
| $T_{10}$, $T_9+B_1$ | 1 628 | 1 707 | 1 667 | 1 682 | 1 806 | 1 744 | 2 067 | 2 241 | 2 154 | 1 914 | 2 030 | 1 972 |
| LSD ($P = 0.05$) | 166 | 104 | 106 | 129 | 133 | 124 | 117 | 182 | 119 | 111 | 124 | 108 |

number of nodules in cowpea and soybean, respectively. Although K application did not improve the nodule production it definitely showed an increase in the number of active nodules in all the cultivars. Applied Zn showed a distinct improvement in the number of active nodules while applied B had no effect on it. Kumar *et al.*(2002) also reported increase in the number of nodulation in cowpea [*Vigna unguiculata* (L.) Walp.] following application of Zinc.

*Dry weight of nodules*

The effects of various nutrient applications on dry weight of nodules (Table 1) were similar to those on the total number of nodules and the number of active nodules produced. Application of graded levels of P significantly increased the dry weight of nodules, while higher levels of applied S did not do so. Applied K and B had no effect on increasing the dry weight of nodules. But application of Zn significantly increased the dry weight of nodules. Ganeshamurthy and Reddy (2000) observed that at higher fertility levels in soybean [*Glycine max* (L.) Merr.] the number of nodules remained same but their dry weight increased, indicating formation of larger size nodules. However, in greengram both nodule production and its size were affected significantly, only if the nutrient was supplied to the level of correcting its deficiency in the soil. At higher fertility levels neither the nodule number nor its size, as indicated by the dry weight was affected. This indicated that at higher fertility the $N_2$ fixation might not increase.

*Total nodules: active nodules ratio*

'PDM 11' and 'PDM 54' had higher proportion of active nodules than 'NM 1' and Samrat. Irrespective of cultivars the proportion of active nodules increased with the application of deficient nutrients (Fig 2). However, at higher levels of applied nutrients, it fell sharply. This indicated that at higher

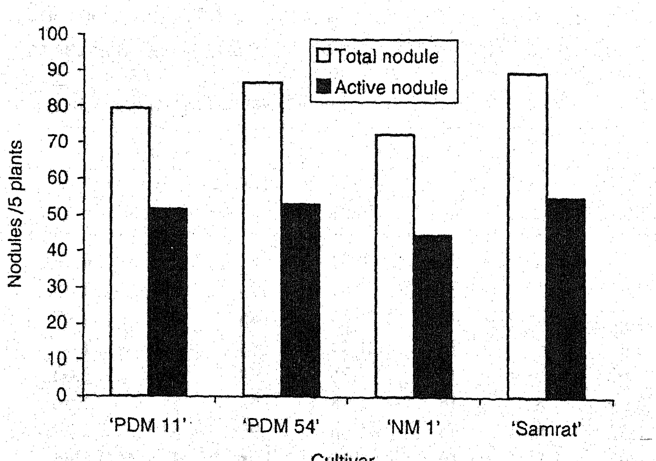


Fig 1 Differences in total nodule and active nodule production in greengram cultivars

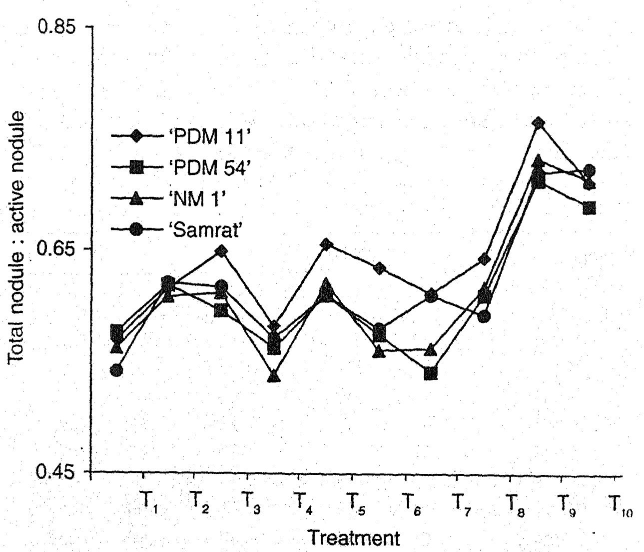


Fig 2 Effect of nutrient application on total nodule : active nodule in greengram cultivars ($T_1 = N_{20}$, $T_2 = T_1+P_{20}$, $T_3 = T_1+P_{40}$, $T_4 = T_1+P_{60}$, $T_5 = T_4+S_{20}$, $T_6 = T_4+S_{40}$, $T_7 = T_4+S_{60}$, $T_8 = T_7+K_{60}$, $T_9 = T_8+Zn_5$, $T_{10} = T_9+B_1$)

Table 3 Simple correlation of seed yield with total nodules, active nodules and total nodule : active nodules in greengram cultivars

| Cultivar | Total nodule | Active nodule | Total nodule: active nodule |
|---|---|---|---|
| 'PDM 11' | 0.971 | 0.873 | 0.960 |
| 'PDM 54' | 0.985 | 0.924 | 0.984 |
| 'NM 1' | 0.977 | 0.912 | 0.977 |
| 'Samrat' | 0.941 | 0.817 | 0.966 |
| All cultivars | 0.688 | 0.705 | 0.733 |

All values are significant at $P = 0.05$ level

fertility levels, although nodule production showed an increasing trend they were ineffective in fixing the dinitrogen in this soil. This is further supported by the results that dry weight of the nodules, an indicator of size of the nodule and effectivity also did not show any increase with increasing levels of fertility.

*Biomass production*

The dry-matter yield recorded at the end of peak growth was significantly influenced with the application of nutrients and their levels (Fig. 3). 'PDM 54' gave maximum biomass and the least 'PDM 11'. There was an average 2-fold increase in biomass production due to P application and 2.5-fold increase owing to S application. Dry-matter was significantly higher at higher levels of applied P in all the cultivars. However, the effect of applied S on dry-matter production could not be seen beyond 20 kg S/ha. Although statistically not significant, dry-matter showed increasing trend with the application of K, Zn and B.

*Effect on seed yield*

Seed yield of greengram increased significantly with the application of nutrients at different levels (Table 2). Among the 4 cultivars of greengram 'NM 1' recorded highest seed yield followed by 'Samrat', 'PDM 54' and 'PDM 11'. There was significant response to applied P up to 17.5 kg P/ha in all the cultivars. Highest response was found in 'PDM 11' (766 kg/ha) followed by 'Samrat' (674/ha), 'NM 1' (672/ha) and least in 'PDM 54' (659/ha). The yields at higher rates reached a plateau and did not increase further. The initial soil test P was low (7.1 and 7.9 kg/ha). Hence greengram responded favourably to the application of P. Our results support earlier studies which indicated that greengram responded to up to 17.5 kg P/ha on Inceptisols (Ganeshamurthy *et al.* 2002). Similarly, large differences were observed among cultivars in response to applied S. All the cultivars responded to applied S up to 20 kg S/ha. 'Samrat' showed maximum response of 288 kg/ha followed by 225 kg in 'NM 1', 196 kg in 'PDM 54' and 158 kg in 'PDM 11'. The yields at higher levels of applied S attained plateau and did not show any response in any of the 4 cultivars. Similar to P, the initial soil test S in the 2 experimental sites were low compared with the critical level of 10 mg S/kg soil (Srinivasarao *et al.* 2002). Hence crops responded favourably to application of S. Ganeshamurthy and Saha (1999) reported that large area in the alluvial belt of Indogangetic plain are S deficient and crops respond to applied S. Our results support also the earlier studies which showed that greengram can respond to applied S in alluvial soils (Ali *et al.* 2002). Cultivars 'Samrat' and 'NM 1' responded significantly to the application of 5 kg Zn/ha while 'PDM 11' and 'PDM 54' did not show significant response to applied Zn. 'Samrat' gave a response of 141 kg/ha while it was 125 kg/ha in 'NM 1'. This shows that even though the DTPA Zn content of the soil was low some cultivars like 'PDM 11' and 'PDM 54' can efficiently extract Zn from soil source while the other two cultivars depend more on the applied Zn and

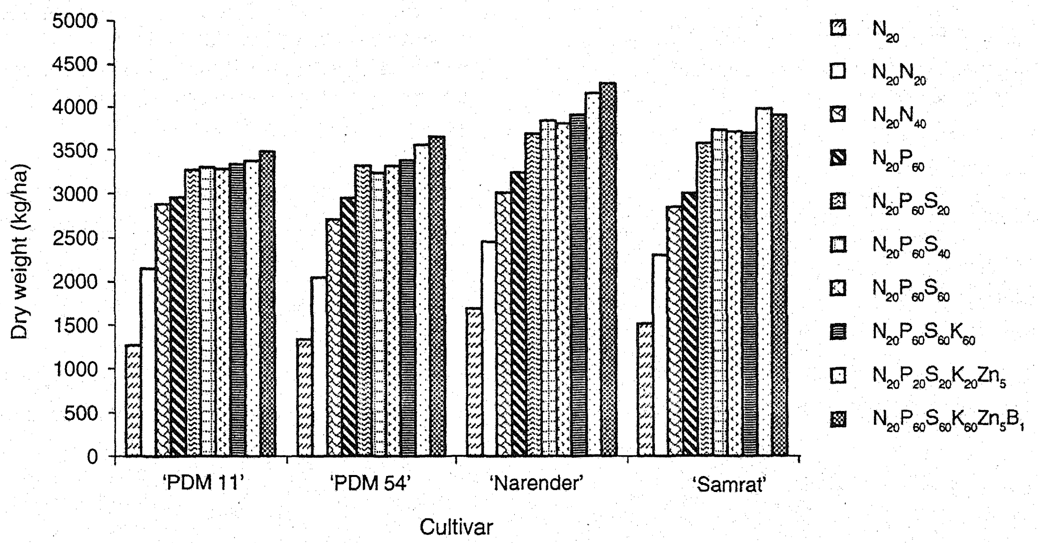


Fig 3 Effect of balanced fertilization on nodulation in greengram cultivars

showed significant response in terms of increased seed yield. Though available B content of the soil was low mungbean did not respond to applied B. This is partly because of the low B requirement of the crop and also due to better ability of the crop to utilize effectively the soil B.

The relationship between seed yield and nodulation were worked out for individual cultivars as well as for the pooled data. It was found that both total number of nodules and total nodule to active nodule ratio showed highly significant correlation with seed yields (Table 3). The number of active nodules was also significantly correlated with seed yield but the r values were lower than those obtained with total nodules. In spite of this, yields of different cultivars were not commensurate with the nodulation. The extent of nodulation recorded was in the order 'Samrat' > 'PDM 54 ' > 'PDM 11' > 'NM 1'. But the seed yields were in the order 'NM 1' > 'Samrat' > 'PDM 54' > 'PDM 11'. This shows that the nodulation in different cultivars cannot be used to compare yield performances among different cultivars.

The results of the experiment showed wide gap in yield of greengram between the treatments, and there is scope to bridge this gap through balanced fertilization in alluvial soils. Large differences were observed among cultivars in response to applied phosphorus and sulphur. Cultivar 'Samrat' and 'NM 1' responded significantly to application of zinc, while 'PDM 11' and 'PDM 54' did not show any response to applied zinc. The benefit that greengram can derive from nutrient application may be limited to the level of their deficiency corrections in the soil. Higher fertility levels did not benefit the crop in terms of their ability to nodulate to acquire atmospheric nitrogen or to produce higher yields. The study also shows that the nodulation in different cultivars cannot be used to compare yield performances among different cultivars and that the greengram yields could be boosted through balanced fertilizer application in the alluvial soil belt.

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