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Nishant Srivastava
M. Sc. Research Scholar, Dept. of Agronomy, Naini Agricultural Institute Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh India

Joy Dawson
Associate Professor Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh India

Ritesh Kumar Singh
M. Sc. Research Scholar Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh India.

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Correspondence
Nishant Srivastava
M. Sc. Research Scholar, Dept. of Agronomy, Naini Agricultural Institute Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh India.

Interaction effect of spacing, sources of nutrient and methods of zinc application on yield attributes and yields of greengram (*Vigna radiata* L.) in NEPZ

Nishant Srivastava, Joy Dawson and Ritesh Kumar Singh

Abstract
A field experiment was conducted during *Zaid* season of 2015-16 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Allahabad. The experiment consisted of two different spacings (30 cm × 10 cm and 45cm × 6.7 cm), three sources of nutrient (100% Organic, 50% Organic + 50% Inorganic and 100% Inorganic on the basis of N & K) and three methods of Zn application (No application, Soil application at 12.5 kg $ZnSO_4$ ha^{-1} and foliar spray at 0.5% $ZnSO_4$) which was laid out in Factorial Randomised Block Design (FRBD) with three replications. Thus, there were in all 18 treatment combinations. The result revealed that greengram grown during *zaid* season with the spacing of 30 cm × 10 cm along with nutrient sources 50% Organic (1.50 tonne Farm Yard Manure ha^{-1} + 83.35 kg Bone meal ha^{-1}) + 50% Inorganic (55.56 kg Diammonium phosphate ha^{-1} +12.50 kg Muriate of Potash ha^{-1}) and Soil application of Zn at 12.5 kg $ZnSO_4$ ha^{-1}, recorded highest number of seeds pod^{-1} which attributed in obtaining highest grain yield. Also, highest net return and benefit-cost ratio was recorded in same treatment.

Keywords: Summer greengram, Spacing, Integrated sources of nutrient, Organic, Farm Yard Manure, Bone Meal and Economics.

Introduction
Pulses are commonly known as food legumes which are secondary to cereals in production and consumption in India. The United Nations, declared 2016 as "International Year of Pulses" (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. Green gram [*Vigna radiata* (L.) Wilczek] also known as Mungbean is a selfpollinated leguminous crop which is grown during *Kharif* (July- October) as well as summer (March- June) seasons in arid and semiarid regions of India. The farmers usually grow Mungbean without maintaining proper planting density. Improper spacing reduced the yield of Mungbean up to 20 to 40% due to competition for light, space, water and nutrition. Optimum spacing favours the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients (Miah *et al*. 1990). The most limiting factor that has affected the production of crops and productivity of Indo Gangetic plain is fertilizer: through imbalanced and indiscriminate use on one hand and withdrawal of organic matter from the schedule of inputs on the other (Kumar *et al.*, 2008). Therefore integrated nutrient management (INM) has been an increasing necessity especially for the sub-tropical Indian soils. An application of organic manure along with fertilizer not only increases the efficiency of the latter, but also has beneficial effects on the succeeding crop and soil. Despite several hurdles, for overall interest of sustaining soil productivity, the use of organic manure has to be encouraged. Intensive agriculture coupled with continuous use of NPK fertilizers has remarkably increased production but simultaneously brought about problems related to micronutrient deficiencies, particularly that of Zn in soil. Zinc is one of the essential plant micronutrients and its importance for crop productivity is similar to that of major nutrients. Lack of zinc causes deficiency in formation Of RNA and protein. Therefore, the plant with lack of zinc is poor in amount of protein.
Therefore, keeping the above facts in view, the present investigation was undertaken to examine the integrated impact of spacing, sources of nutrient and method of zinc application on yield attributes, productivity and economics of greengram.

Materials and Methods
The experiment was carried out during *Zaid* season of 2015-16 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Allahabad, which is located

at 25^0 24' 42" N latitude, 81^0 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5 km away from Allahabad city.

The soil was sandy loam with pH 7.4, organic carbon 0.43%, available nitrogen 235.25 kg/ha, phosphorus 15.60 kg/ha, potassium 345.22 kg/ha and Zn status of 0.84 ppm. The treatments comprised of two different spacings (30 cm × 10 cm and 45cm × 6.7 cm), three sources of nutrient (100% Organic, 50% Organic + 50% Inorganic and 100% Inorganic on the basis of N & K) and three methods of Zn application (No application, Soil application at 12.5 kg $ZnSO_4$ ha^{-1} and foliar spray at 0.5% $ZnSO_4$) which was laid out in Factorial Randomised Block Design (FRBD) consisting of eighteen treatment combinations with three replications; plot size was 2.5 x 2.7 m for crop seed rate is 25 kg ha^{-1} (*Vigna radiata* L.) Cv. Samrat PDM-139. Greengram was sown on 12th April 2016 and the recommended dose was 20 kg N + 50 kg P_2O_5 + 15 kg K_2O/ha. Full dose of Nitrogen, phosphorus and potassium applied as Di-ammonium phosphate and Muriate of potash for inorganic sources of nutrient and Farm yard manure + Bone meal for organic sources of nutrient on the basis of N & K was applied at the time of sowing of greengram. Zn is applied in the form of $ZnSO_4$ as basal at the time of sowing and as foliar spray at 25 and 45 DAS in defined plots according to treatment combinations. The rainfall during the crop season was 9.4 mm in 5 rainy days occurred from sowing to harvesting during 2016.The other usual common packages of practices were followed time to time and periodical growth observations were recorded at an interval of 15 days. The crop was harvested on 9th June. At harvest, grain and straw yield of crop were recorded. Nitrogen content in grain was determined by modified Kjeldahl's method (Jackson, 1973). Economics and system productivity were calculated the basis of prevailing market prices.

Results and Discussion

Yield Attributes

The data revealed that the interaction effect was found to be non-significant for pods $plant^{-1}$ and seeds pod^{-1}. The highest number of pods $plant^{-1}$ was observed in treatment T_{14} [45cm × 6.7cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)].Whereas, the highest number of seeds pod^{-1} was found with the treatment combination T_5 [30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)]. The interaction effect was found to be significant for test weight. The highest value of test weight was found with the treatment combination T_8 [30cm × 10cm + 100% Inorganic + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)]. However, treatments T_{14} [45cm × 6.7cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)] and T_5 [30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)] were found statistically on a par with T_8 [30cm × 10cm + 100% Inorganic + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)].

The possible reason for increasing yield attributes may be due to integrated use of organic with inorganic fertilizers might be attributed to better supply of nutrients along with conducive physical environment leading to better root activity and higher nutrient absorption, which resulted better yield attributes. Similar finding was reported by Thakur *et al.* (2011) [8]. In soybean-wheat cropping system. The addition of $ZnSO_4$ could have increased the availability of micronutrients in soil as well as increased the rate of photosynthesis, also due to application of $ZnSO_4$ could have enhanced the plant nutrition increases the assimilate production and photosynthesis efficiency at seed filling stage. This result is similar to those reported by Keerthi *et al*. (2015) [3]. in greengram.

Yields and Harvest Index

The interaction effect was found to be non-significant for grain yield. However, the highest grain yield was observed in treatment T_5 [30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)]. The interaction has significant effect on stover yield. Highest stover yield was observed in treatment T_1 [30cm × 10cm + 100% Organic + Fertilized Control (Recommended NPK)]. However, treatment T_6 [30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 0.5% (as foliar)] was statistically at par with T_1 [30cm × 10cm + 100% Organic + Fertilized Control (Recommended NPK)]. The interaction effect was found to be non-significant for harvest index. However, the highest harvest index was observed in treatment T_5 [30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)].

The credible reason for increasing grain yield may be due to under 45cm x 6.7 cm the less intra row spacing increases competition for solar radiation that ultimately stunt growth of some intra row plants in vegetative phase and they were unable to reach reproductive phase, even though the yield contributing variables were high when compared to the recommended spacing, the productivity was low due to lesser plant population reached to reproductive phase. According to Sarkar *et al*. (2004) [7]. greengram planted at a spacing of 30 x 10 cm significantly produced the highest seed yield. Integration of inorganic fertilizers and organic manures resulted in better yield in greengram may be due to organic manures provide a good substrate for the growth of micro-organisms and maintain a favourable nutrient supply environment and improve soil physical properties. Similar findings were reported by Mandal and Pramanick (2014) [5].

Economics

The highest net return and benefit cost ratio was recorded in treatment T_5 [30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)].

The feasible reason for increasing net returns and benefit cost ratio may be organic sources in a combination with inorganic sources proved vital in attaining economical harvests that emphasize the need to adopt integrated nutrient management. This will result into increasing farmer's premiums as well as maintain soil nutrition. Similar finding in mungbean was reported by Aslam *et al.* (2010).

It is concluded that spacing at 30 cm x 10 cm in combination with 50% organic (1.5 tonne FYM ha^{-1} + 83.35 kg Bone Meal ha^{-1}) + 50% Inorganic (55.55 kg DAP ha^{-1} +12.5 kg MOP ha^{-1}) with $ZnSO_4$ at 12.5 kg ha^{-1} (as basal), recorded highest number of seeds pod^{-1} (10.40) which attributed in obtaining highest grain yield (893.83 kg ha^{-1}) in greengram. Also, highest net return (26617.50) and benefit-cost ratio (2.21) was recorded in same treatment.

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Table 1: Integration effect of spacing, nutrient sources and methods of zinc application on yield attributes, yields, harvest index and economics of greengram at harvest stage.

	Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)	Net return* (ha^{-1})	B: C Ratio*
1.	30cm × 10cm + 100% Organic + Fertilized Control (Recommended NPK)	11.89	8.93	37.50	711.11	2896.30	19.68	17264.00	1.76
2.	30cm × 10cm + 100% Organic + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)	13.11	8.87	39.44	770.37	2523.46	23.31	18904.50	1.81
3.	30cm × 10cm + 100% Organic + $ZnSO_4$ at 0.5% (as foliar)	10.89	9.07	36.68	750.62	2553.09	22.64	18149.50	1.78
4.	30cm × 10cm + (50% Organic + 50% Inorganic) + Fertilized Control (Recommended NPK)	10.56	9.07	38.63	780.25	2533.33	23.52	21589.50	2.02
5.	30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)	13.22	10.40	40.14	893.83	2585.19	25.63	26617.50	2.21
6.	30cm × 10cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 0.5% (as foliar)	10.78	9.27	39.24	839.51	2748.15	23.43	24312.00	2.11
7.	30cm × 10cm + 100% Inorganic + Fertilized Control (Recommended NPK)	12.56	8.53	36.37	745.68	2402.47	23.77	21113.00	2.07
8.	30cm × 10cm + 100% Inorganic + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)	14.22	9.40	41.28	834.57	2427.16	25.54	24850.50	2.21
9.	30cm × 10cm + 100% Inorganic + $ZnSO_4$ at 0.5% (as foliar)	12.56	9.33	38.50	800.00	2385.19	24.91	23187.50	2.14
10.	45cm × 6.7cm + 100% Organic + Fertilized Control (Recommended NPK)	11.78	9.07	36.20	681.48	2409.88	22.03	15035.00	1.66
11.	45cm × 6.7cm + 100% Organic + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)	14.33	9.27	38.15	740.74	2555.56	22.45	17504.00	1.75
12.	45cm × 6.7cm + 100% Organic + $ZnSO_4$ at 0.5% (as foliar)	12.89	9.20	37.02	725.93	2491.36	22.54	16806.50	1.72
13.	45cm × 6.7cm + (50% Organic + 50% Inorganic) + Fertilized Control (Recommended NPK)	13.78	9.40	37.13	730.86	2491.36	22.67	19076.50	1.90
14.	45cm × 6.7cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)	17.78	9.87	40.18	834.57	2545.68	24.68	23609.00	2.08
15.	45cm × 6.7cm + (50% Organic + 50% Inorganic) + $ZnSO_4$ at 0.5% (as foliar)	17.00	9.40	39.87	795.06	2607.41	23.35	21850.50	2.00
16.	45cm × 6.7cm + 100% Inorganic + Fertilized Control (Recommended NPK)	13.56	9.33	36.64	716.05	2501.23	22.20	19761.50	2.00
17.	45cm × 6.7cm + 100% Inorganic + $ZnSO_4$ at 12.5 kg ha^{-1} (as basal)	16.44	9.67	39.43	800.00	2590.12	23.54	23345.00	2.14
18.	45cm × 6.7cm + 100% Inorganic + $ZnSO_4$ at 0.5% (as foliar)	14.89	9.60	37.48	775.31	2466.67	23.87	22060.50	2.08
	F test	NS	NS	S	NS	S	NS	-	-
	SEm (±)	0.77	0.29	0.45	54.48	61.67	1.25	-	-
	CD (P = 0.05)	-	-	1.28	-	177.24	-	-	-

* Data was not subjected to statistical analysis

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