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Growth Efficiency and Yield of Pigeonpea (*Cajanus cajan* L.) as Affected by Foliar Application of Mineral Nutrients

Research Article

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Abstract

The study was conducted to determine the effect of foliar application of mineral nutrients on growth attributes of two pigeonpea varieties (PAU 881 and AL 201) for two successive seasons (2012-2013). Both the varieties showed identical pattern of results for plant height, number of branches, leaf area, leaf area index (LAI), specific leaf weight (SLW), crop growth rate (CGR) and relative growth rate (RGR). All the treatments of mineral nutrients (1mM CaCl2, 2mM CaCl2, 0.5% KNO3, 1% KNO3, 0.1% MgCl2, 0.2% MgCl2, 1% urea and 2% urea) had positive effect on growth attributes. Amongst all the treatments, 2% urea application caused maximum increase in growth attributes viz., plant height, number of branches, leaf area, LAI, SLW, CGR and RGR. These growth attributes showed significant positive correlation with yield. Thus, the application of mineral nutrients improved yield of pigeonpea varieties through enhancement of various growth attributes.

Keywords: Pigeonpea; Mineral nutrients; Growth attributes

Introduction

Pigeonpea is a multipurpose crop, used for fodder, soil fertility enhancement, soil erosion control and for fuel. Minor uses include indigenous medicinal practices which generally involve a pain relieving effect [1]. However, yield of pigeonpea remains low due to excessive vegetative growth, inderminate growth habit and poor source-sink relationship [2]. Nutrient elements are needed in relatively very small quantities for adequate plant growth and production. Their deficiency may cause great disturbances in the physiological and metabolic processes, involved in the plant [3]. Nitrogen is a chlorophyll component, it promotes vegetative growth and is a necessary component of vitamins that aids in production and use of carbohydrates as well as influence energy reactions in plants [4]. K is essential for many physiological processes, such as photosynthesis, translocation of photosynthates into sink organs, maintenance of turgidity and activation of enzymes [5]. Calcium is another important mineral nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth and development as well as general fruit quality [6]. Further, magnesium plays specific role in chlorophyll formation, activation of enzymes, synthesis of proteins and energy transfer [7]. Application of nutrients through foliar spray at appropriate stages of growth becomes important for their utilization and better performance of crop [8]. Urea is one of the most widely used foliar N-fertilizers, characterized by high leaf penetration rate and low cost and most plants can absorb it rapidly and hydrolyse in the cytosol [9]. Foliar application of urea with recommended dose of fertilizer could give higher seed yield in niger [10]. Similarly, foliar application of $Ca(NO_3)_2$ and KNO_3 enhanced the growth and yield attributes of rice plant [11]. Further, Saad et al. reported that foliar application of magnesium sulphate enhanced the yield of faba bean [12]. Thus, the present investigation was planned to study the influence of foliar application of mineral nutrients on some of the growth attributes of pigeonpea [Table 1] [Figure 1].

Material and Method

This experiment was conducted in Punjab Agricultural University, Ludhiana during *Kharif* season of 2012-13 and 2013-14. The soil was sandy loam in texture with 318.7 kg $ha^{-1}$of N, 268 kg $ha^{-1}$of K, 1.6 meq/lt of Ca and 1.0 meq/lt of Mg. The experiment consisting of two pigeonpea varieties (PAU 881 and AL 201) having one control and eight treatments was laid out in randomized block design with three replications. The treatments: Control (water), T_1 (1mM $CaCl_2$), T_2 (2mM $CaCl_2$), T_3 (0.5% KNO_3), T_4 (1% KNO_3), T_5 (0.1 % $MgCl_2$), T_6 (0.2 % $MgCl_2$), T_7 (1 % urea) and T_8 (2 % urea) were applied as foliar spray at green floral bud stage of inflorescence followed by another spray after 2 days. Five plants from each replication of each treatment were taken for recording the following traits: Plant height (cm), Number of branches, Leaf area (cm^2 $plant^{-1}$), Leaf area index, Specific leaf weight (mg cm^{-2} $plant^{-1}$), Crop growth rate (g m^{-2} day^{-1}) and Relative growth rate (g g^{-1} DW day^{-1}) [Figure 2-5]. Leaf area was calculated by graph paper method and then samples were dried at 70 ˚C till weight stability in an electric oven and then weighed. These traits were calculated using following formulae:

$$\text{Leaf area index (LAI)} = \frac{\text{LA plant}^{-1} \text{ x total no. of plants}}{\text{Surface Area}}$$

$$\text{Specific Leaf Weight} = \frac{\text{Leaf weight (mg)}}{\text{Leaf area (cm}^2\text{)}}$$

$$\text{CGR} = \frac{W_2 - W_1}{[SA] \times (t_2 - t_1)}$$

Where, W_1 and W_2 = crop dry weight at the beginning and at the end of the interval, t_1 and t_2 = corresponding days, SA= soil area occupied by the plant during each sampling

$$\text{RGR} = \frac{dW}{t} \times \frac{1}{W_0}$$

Where dW = increase in dry matter in time 't', t = time interval in days, W_0 = initial dry matter in mg

Yield: Five plants were selected at random from each treatment for recording seed yield per plant at maturity and weighted using an electric balance.

Results

Plant height and number of branches

Plant height and number of branches increased with crop age and changes in these traits with different treatments were apparent at all the growth stages of both the varieties. All the treatments of mineral nutrients caused significant increase in number of branches and plant height in both the varieties at all developmental stages. Maximum enhancement in these traits were observed with 2% urea application which was approximately 13% in plant height and 58% in number of branches at flowering stage of development as compared to control. This increase with 2% urea application, at podding stage was approximately 22% in plant height and 40% in number of branches. Increase in plant height and number of branches could be the result of increased metabolic and divisional activities in the

Table 1: Effect of foliar application of various mineral nutrients on Specific leaf weight (mg cm^{-2} $plant^{-1}$) in pigeonpea varieties at different growth stages.

Vegetative stage				
Specific leaf weight (mg cm^{-2} $plant^{-1}$)				
PAU 881			AL 201	
3.53			4.21	
Treatments	Specific leaf weight (mg cm^{-2} $plant^{-1}$)			
	Flowering stage		Podding stage	
	PAU 881	AL 201	PAU 881	AL 201
Control	7.39±0.23	7.49±0.17	8.43±0.59	8.94±0.61
T_1	7.60±0.22	7.81±0.17	8.64±0.56	9.07±0.59
T_2	7.81±0.23	7.79±0.16	9.56±0.53	9.11±0.56
T_3	7.65±0.24	7.58±0.16	10.27±0.54	10.64±0.49
T_4	7.99±0.24	7.61±0.18	10.26±0.56	10.58±0.55
T_5	8.23±0.25	7.56±0.21	9.15±0.58	9.35±0.62
T_6	7.68±0.25	7.49±0.19	10.64±0.57	10.11±0.47
T_7	8.29±0.26	7.76±0.08	10.43±0.60	11.72±0.03
T_8	8.83±0.26	8.00±0.05	11.62±0.63	11.63±0.01

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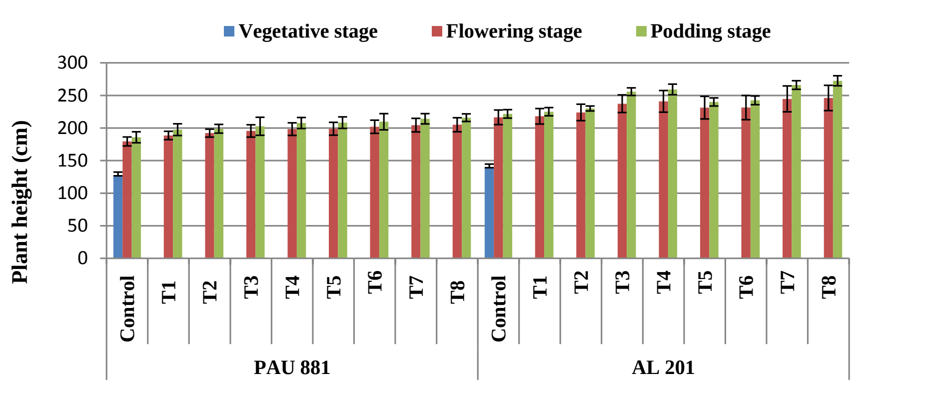

Figure 1: Effect of foliar application of mineral nutrients on plant height (cm) of pigeonpea varieties at different growth stages.

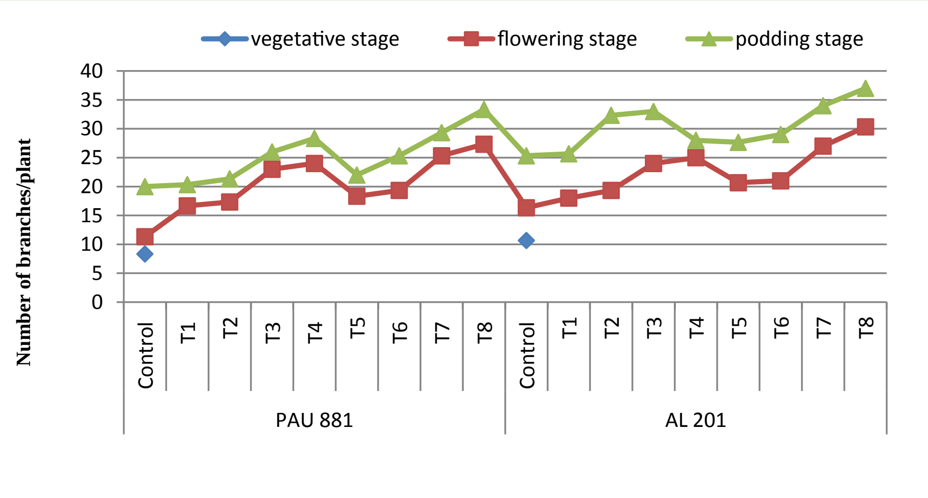

Figure 2: Effect of foliar application of mineral nutrients on number of branches/plant in pigeonpea varieties at different growth stages.

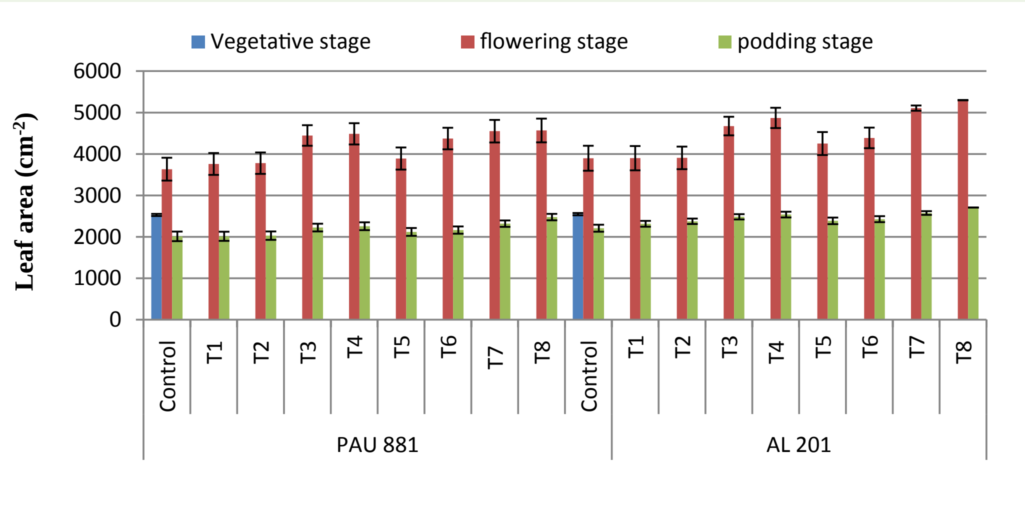

Figure 3: Effect of foliar application of mineral nutrients on leaf area (Cm-2) of pigeonpea varieties at different growth stages.

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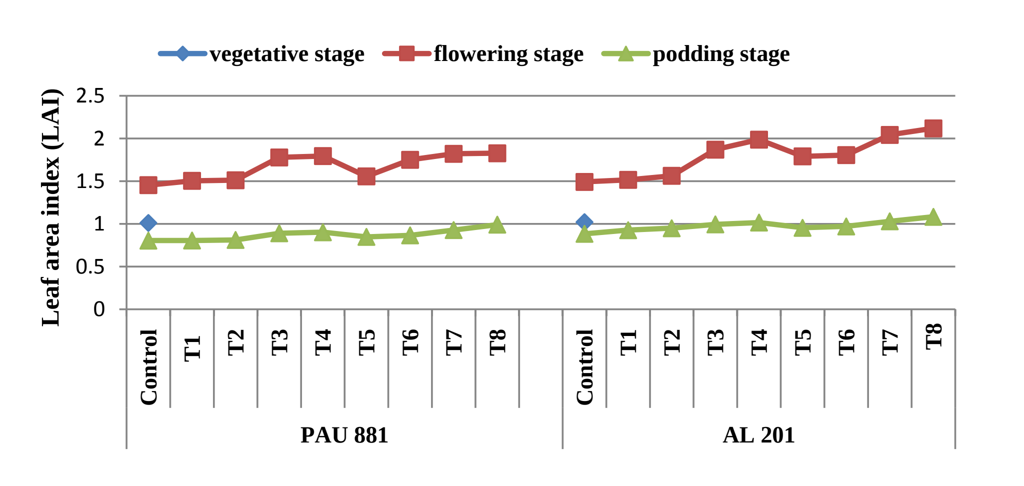

Figure 4: Effect of foliar application of mineral nutrients on leaf area index of pigeonpea varieties at different growth stages.

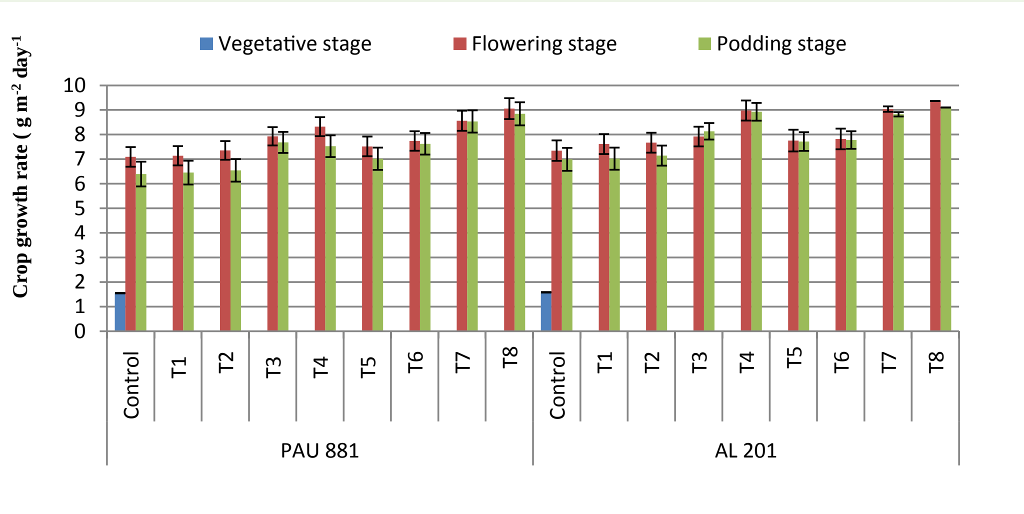

Figure 5: Effect of foliar application of mineral nutrients on crop growth rate (CGR) (g m-2 day-1) in pigeonpea varieties at different growth stages.

shoot apical meristems in response to nutrients applications. Our results are in close agreement with those obtained by Parimala et al. in chickpea. According to our results, applications of 2% urea recorded maximum plant height and number of branches per plant. This might be due to more availability of nitrogen, which plays a vital role in cell division.

Leaf characteristics

Leaf area is considered to be one of the photosynthetic determinants in crop plants and in the present study, it increased gradually from vegetative to flowering stage and decreased thereafter due to senescence and ageing of leaves. Mineral nutrient treatments significantly enhanced the leaf area and LAI at all the stages of development in both the varieties. Maximum increase in leaf area and LAI was noted with 2% urea application which was 26% at flowering and 19% at podding stage of development as compared to control. In the present study, application of different mineral nutrients increased leaf area and leaf area index obtained in our results is concurrent with results of Govindan et al. [14]. Where a significant increase in LAI in green gram with the foliar spray of KNO_3 (1%) or KCl (1%) and their combination was reported. Similary, Khalilzadeh et al. observed higher leaf area in urea treated plants of mungbean [15]. In our study, magnesium and calcium treatments also increased leaf area and leaf area index and these results are in good agreement with results of Howladar et al. in *Pisum sativum* [16].

SLW also showed a similar pattern as that of LA and LAI. At podding stage, maximum increase in SLW was observed with 2% urea application in PAU881 *i.e.* 27.49% more as compared to control while in AL201 maximum increase was noticed with 1 % urea treatment *i.e.* 23.72% over the control plants. Specific leaf weight is measure of leaf thickness and positively correlated with

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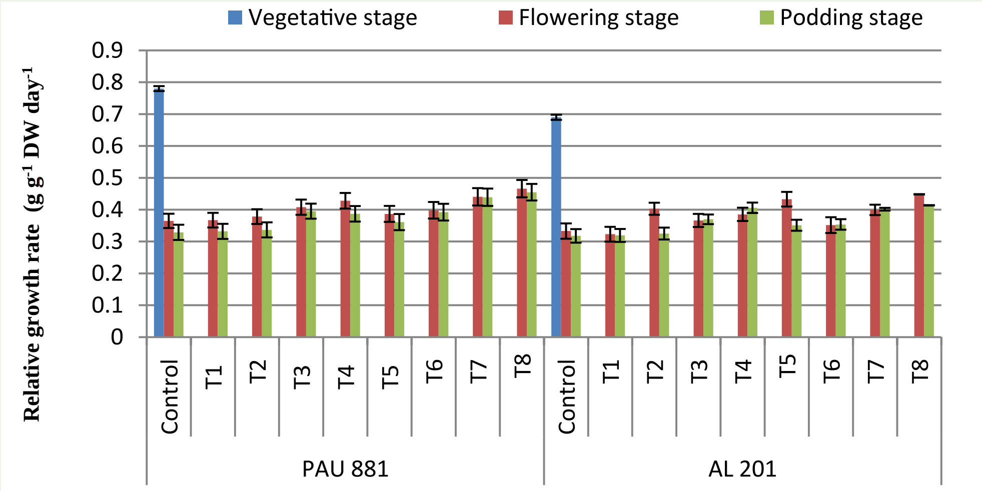

Figure 6: Effect of foliar application of mineral nutrients on relative growth rate (RGR) (g g-1 DW day-1) in pigeonpea varieties at different growth stages.

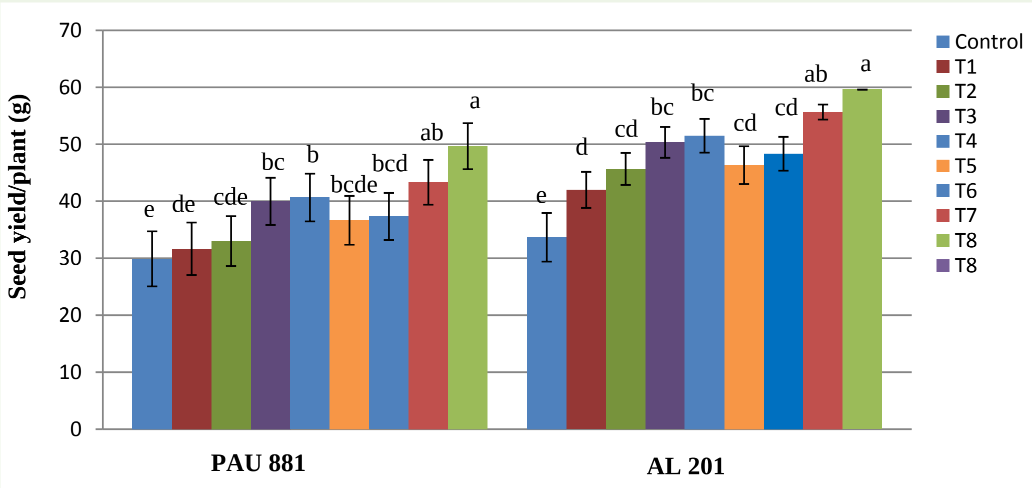

Figure 7: Effect of foliar application of various mineral nutrients on seed weight/plant (grams) in pigeonpea varieties. Error bars denote mean ± SE of three replicates. Bars with different small letter(s) denote significant differences in treatments from their respective controls at P < 0.05: analysed by Dunken's post-hoc test.

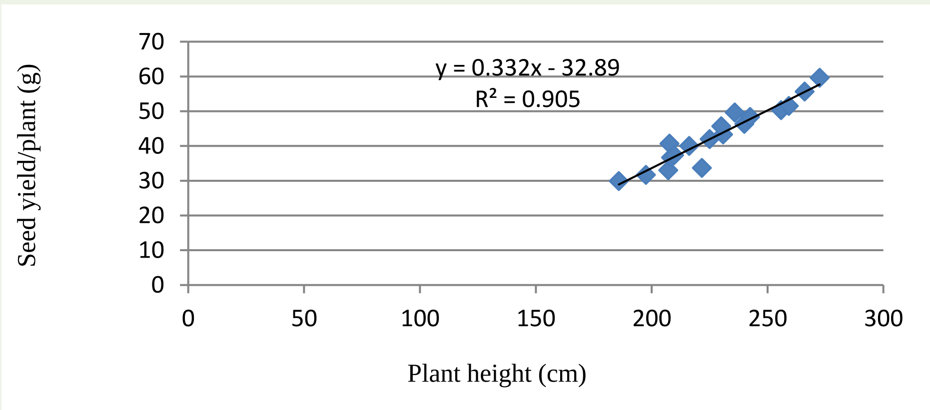

Figure 8: Correlation of plant height with seed yield/plant.

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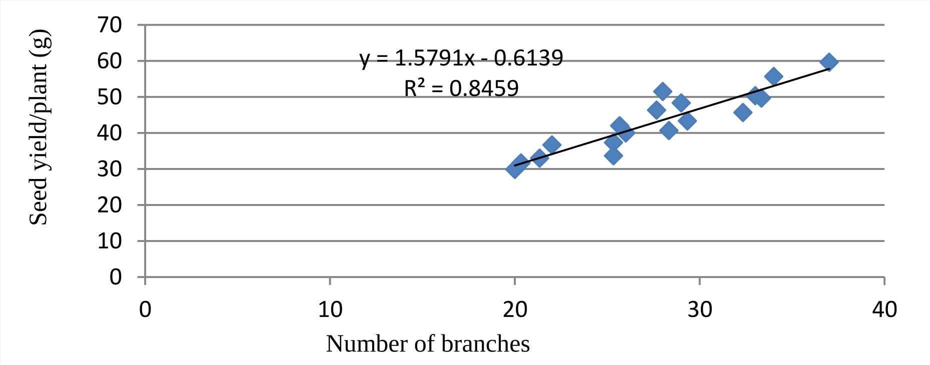

Figure 9: Correlation of number of branches with seed yield/plant.

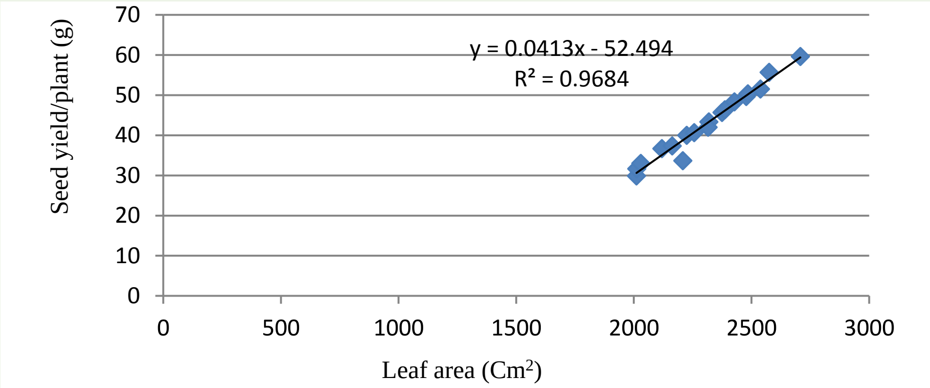

Figure 10: Correlation of leaf area with seed yield/plant.

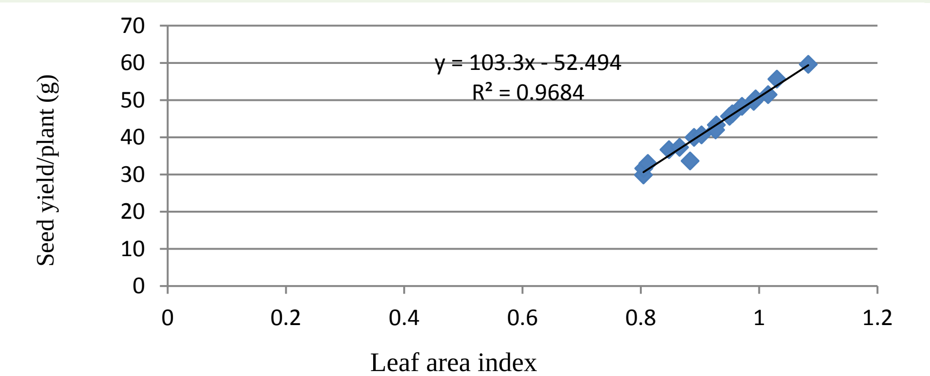

Figure 11: Correlation of leaf area index with seed yield/plant.

leaf photosynthesis. Thicker leaves would have more number of mesophyll cells with high density of chlorophyll and therefore, have a greater photosynthetic capacity than thinner leaves [17].

Growth efficiency

The average daily increment in CGR is an important useful tool for estimating production efficiency, enabling comparison between the treatments. Different treatments of mineral nutrients significantly enhanced the CGR over controls at flowering stage but this increase was non-significant at podding stage. Among the treatments, maximum increase in CGR was observed with 2% urea application which was about 22% increase at flowering stage and about 28% at podding stage in both the varieties as compared to their respective controls. Mir et al. opined that the aspects of interaction of phytohormones and nutrients on growth and development of crop plants cause positive responses on plant growth rate, relative growth rate, crop growth rate and net assimilation rate [18]. Surendar et al. also studied the

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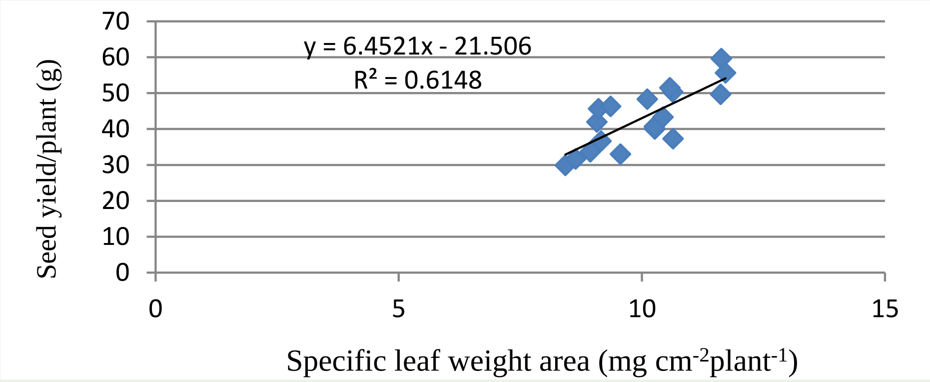

Figure 12: Correlation of specific leaf weight with seed yield/plant.

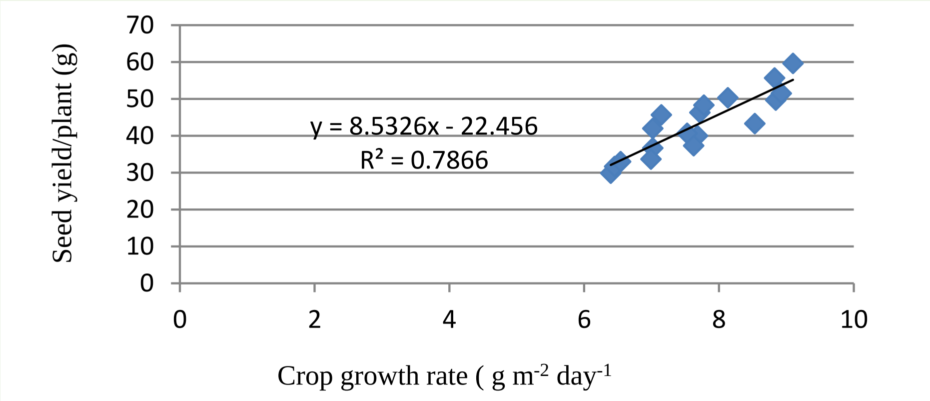

Figure 13: Correlation of Crop growth rate with seed yiled/plant.

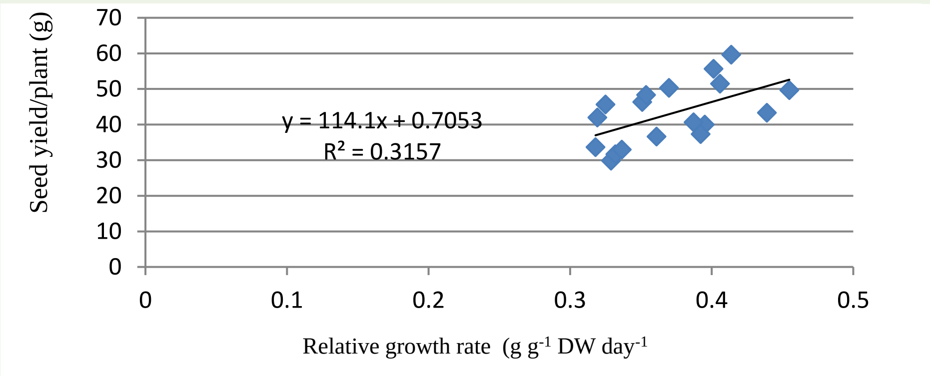

Figure 14: Correlation of Relative growth rate with seed yiled/plant.

physiological effects of nitrogen with foliar spray of urea on crop growth attributes and yield of black gram [19]. They observed that the foliar spray of urea significantly expressed the higher values in growth attributes *viz.,* leaf area index, crop growth rate, net assimilation rate and specific leaf weight by showing higher accumulation of total dry matter production with increased yield.

Mineral nutrients application significantly enhanced the RGR in both the varieties at all the stages of development as compared to their respective controls. At flowering stage, maximum enhancement in RGR was noticed with 2% urea which was 21.71 (PAU 881) and 25.71 (AL 201) per cent high over controls. At this stage, all the treatments significantly enhanced RGR over controls but there was non-significant difference among the treatments. However, at podding stage, significant difference in RGR was observed among the treatments and controls. At this stage

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maximum RGR (0.454 g g^{-1}dw day^{-1}in PAU 881and 0.414 g g^{-1}dw day^{-1} in AL 201) was obtained with 2% urea which was 27.69 (PAU 881) and 23.17 (AL 201) per cent high over their controls. Increase in RGR in treated plants can be attributed to increased leaf longevity in these plants as compared to their controls. This could also be due to increased photosynthetic efficiency by retaining more chlorophyll content and efficient translocation. These results are supported by the finding of Gowthami et al. in soybean [20]. They found higher RGR in potassium treated plants and reported that it might be due to high leaf area and crop growth rate in treated plants as reflected through total dry matter accumulation.

Seed yield/plant

An increase in seed yield/plant was recorded following mineral nutrients application and maximum increase was observed with 2% urea application which was 1.66 (PAU 881) and 1.77 (AL 201) fold over controls followed by 1% urea (1.45 fold in PAU 881 and 1.65 fold in AL 201). Almost all the mineral nutrient treatments significantly enhanced seed yield per plant in both the varieties (except for $CaCl_2$ in PAU 881 where, a non-significant increase in seed yield/plant was observed). Gowthami et al. also observed an increase in seed yield/plant with urea and DAP application in soybean [21]. According to Jones et al. the wider and flat leaf surface enables the plant to absorb maximum light [22]. The improvement in leaf characteristics (LA and LAI) as observed in our study might have contributed towards enhanced production of assimilates through improved photosynthetic efficiency (as SLW was also more in treated plants). This improvement in leaf characteristics can be considered as main factor responsible for increased yield in pigeonpea.

Correlation studies

The final yield of a crop is the cumulative effect of various growth attributes and the treatments which manipulate these favourable parameters could result in the positive relationship resulting in higher productivity. The relationship of plant height, number of branches, leaf area, leaf area index, specific leaf weight, crop growth rate and relative growth rate were correlated with final seed yield and are presented in Figures 6-14. These results revealed that the plant height, number of branches, leaf area, leaf area index, specific leaf weight, crop growth rate and relative growth rate were significantly and positively correlated with yield.

Conclusion

Thus it can be concluded that the mineral nutrients especially nitrogen and potassium as urea and KNO_3, respectively, can be used for improving growth efficiency and ultimately yield in pigeonpea.

Acknowledgement

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References

1. Pahwa K, Ghai N, Bedi S (2013) Pigeonpea: A potential multipurpose crop. Rashtriya krishi 8: 62-64.
2. Babaeian M, Piri I, Tavassoli A, Esmaeilian Y, Gholami H (2011) Effect of water stress and micronutrients (Fe, Zn and Mn) on chlorophyll fluorescence, leaf chlorophyll content and sunflower nutrient uptake in Sistan region. African J Agric Res 6: 3526-3531.
3. Chandrasekhar CN, Bangarusamy U (2003) Maximizing the yield of mung bean by foliar application of growth regulating chemicals and nutrients. Madras Agric J 90: 142-145.
4. Sara S, Morad M, Reza CM (2013) Effects of seed inoculation by Rhizobium strains on Chlorophyll content and protein percentage in common bean cultivars (*Phaseolus vulgaris* L.). Int J Biosciences 3: 1-8.
5. Mengel K, Kirkby EA (2001) Principles of Plant Nutrition. 5th ed., Kluwer Academic Publishers, Dordrecht.
6. Shukla AK (2011) Effect of foliar application of calcium and boron on growth, productivity and quality of Indian gooseberry (*Emblica officinalis*). The Indian J Agric Sci 81: 628-632.
7. Thalooth AT, Tawfik MM, Mohamed HM (2006) A Comparative Study on the Effect of Foliar Application of Zinc, Potassium and Magnesium on Growth, Yield and Some Chemical Constituents of Mungbean Plants Grown under Water Stress Conditions. World Journal of Agric Sci 2: 37-46.
8. Anadhakrishnaveni S, Palchamy A, Mahendran S (2004) Effect of foliar spray of nutrients on growth and yield of greengram (*Phaseolus radiatus*). Legume Res 27:149-150.
9. Witte CP, Tiller SA, Taylor MA, Davies HV (2002) Leaf urea metabolism in potato. Urease activity profile and patterns of recovery and distribution of 15 N after foliar urea application in wild-type and urease-antisense transgenics. Plant Physiol 128: 1129-1136.
10. Dalei BB, Kheroar S, Mohapatra PM, Panda S, Deshmukh MR (2014) Effect of Foliar Sprays on Seed Yield and Economics of Niger [*Guizotia abyssinica* (L.f.) Cass]. J Agric Sci 6: 143-147.
11. Kundu C, Sarkar RK (2009) Effect of foliar application of potassium nitrate and calcium nitrate on performance of rainfed lowland rice (*Oryza sativa* L). Indian J Agronomy 54: 428-432.
12. Saad AOM, El-Kholy MA (2000) Response of some faba bean to phosphorus and magnesium fertilization. Egypt J Agronomy 22: 19-32.
13. Parimala K, Anitha G, Reddy AV (2013) Effect of Nutrient Sprays on Yield and Seedling Quality Parameters of Chickpea *(Cicer Arietinum* L.*).* Plant Archives 13: 735-737.
14. Govindan K, Thirumurugan V (2000) Response of green gram to foliar nutrition of potassium. Journal of Maharashtra Agricultural Universities 25: 302-303.
15. Khalilzadeh R, Tajbakhsh M, Jalilian J (2012) Growth characteristics of mungbean (*Vigna radiate* L.) affected by foliar application of urea and bio-organic fertilizers. Int J Agric Crop Sci 4: 637-642.
16. Howladar SM, Osman AS, Rady MM, Al-Zahrani HS (2014) Magnesium Foliar Application and Phosphorien Soil Inoculation Positively Affect *Pisum sativum* L. Plants Grown on Sandy Calcareous Soil. Int J Biol Food Vet and Agricultural Eng 8: 428-432.
17. Craufurd PC, Wheeler TR, Ellis RH, Summer RJ, Williams JH (1999) Effect of temperature and water deficit on water use efficiency, carbon isotope discrimination and specific leaf area in peanut. Crop Sci 39: 136-142.
18. Mir MR, Mobin M, Khan NA, Bhat MA, Lone NA, et al. (2010) Crop Responses to interaction between plant growth regulators and Nutrients. J Physiol 2: 9-19.
19. Surendar KK, Vanagamudi SVM, Vijayaraghavan H (2013) Physiological Effects of Nitrogen and Growth Regulators on Crop Growth Attributes and Yield of Black Gram (*Vigna mungo* L.). Bull Env Pharmacol Life Sci 2: 70-76.

20. Gowthami P, Rama Rao G (2014) Effect of foliar application of potassium, boron and zinc on growth analysis and seed yield in soybean. Int J Food Agric Vet Sci 4: 73-80.

21. Kumar CV, Vaiyapuri K, Amanullah MM, Gopalaswamy G (2013) Influence of foliar spray of nutrients on yield and economics of soybean (*Glycine max* L. Merill). J Biol Sci 13: 563-565.

22. Jones RH, McLeod KW (1990) Growth and photosynthetic responses to a range of light environments in Chinese tallow tree and Carolina ash seedlings. Forest Sci 36: 851-862.

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