



Growth and Productivity as Influenced by Nutrient Management Practices on Pigeon Pea [*Cajanus cajan* (L.) Millsp.] in Upland Alfisols of Tripura

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ABSTRACT

Pigeon pea [*Cajanus cajan* (L.) Millsp.] is the rich sources of dietary protein, carbohydrate & certain minerals but its poor yield needs to formulate a nutrient management practices for higher productivity in upland alfisols of Tripura and to combat it, an experiment was conducted during three consecutive kharif seasons at College of Agriculture, Lembucherra, Tripura comprising of two levels of Lime (150 and 200 kg ha⁻¹) in main plot and two levels of molybdenum seed treatment (0 and 4g kg⁻¹ of seed) in sub plot and 4 levels of recommended doses, viz 0% of RDF ha⁻¹, 50% of RDF ha⁻¹, 75% of RDF ha⁻¹ and 100% of RDF ha⁻¹ (Recommended dose @ 20:60:40 of NPK). It was revealed that by the use of 100% RDF ha⁻¹ with 150 kg ha⁻¹ lime and 4g kg⁻¹ of molybdenum seed treatment leads to higher yield and return per rupee respectively. But by the use of 100% RDF ha⁻¹ with 200 kg ha⁻¹ lime and 4g kg⁻¹ of molybdenum seed treatment, return per rupee was recorded at 2.98. The investigation reflects that by the use of 75% RDF ha⁻¹ return per rupee (3.78) was less compared to 100% RDF ha⁻¹ but significant with saving the cost of 25% RDF ha⁻¹ and soil health from the excessive use of fertilizer for sustaining the agricultural growth.

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Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is the most versatile food legume with diversified uses as food, feed, fodder and fuel. It accounts for 5% of global pulse production. Of the global acreage and production, Asia is nearly the sole contributor and of that too, India alone accounts for over three-fourths of area and four-fifths of production (Ahlawat et al. 2005). Pigeonpea ranks second in both acreage (3.58 million ha) and production (2.74 million tonnes) among the pulses in India with average productivity of 765 kg ha⁻¹. Pigeon pea is the rich sources of dietary protein, carbohydrate & certain minerals in the vegetarian diet in our country (Gopalan et al. 1971). Besides being the major sources of dietary protein, they also plays an important role in sustaining soil productivity by fixing atmospheric nitrogen (Kumar Rao and Dart, 1987). On the upland hill slopes, pigeon pea serves as soil conserving crop and check erosion to some extent. However, there are many factors influencing atmospheric nitrogen fixation through symbiosis. On field condition, soil moisture, temperature, soil pH, mineral nutrient supply, salinity and nodule damage by insects are presumably the most important factors limiting the biological nitrogen fixation (Kumar Rao, 1990). As per as the productivity is concerned, pigeon pea has observed almost stagnation throughout the state. Soil acidity and Al toxicity inhibits and restricts symbiotic nitrogen fixation and root growth respectively (Das, 1996). Again, nutrient limitations result from deficiencies of micronutrients such as molybdenum (Mo), zinc (Zn), boron (B) and iron (Fe) affects legume production (Bhuiyan et al. 1999). Inadequate nodulation of pigeonpea can be associated with low plant available Mo. Increase in flower numbers and pod set improvement are influenced by Mo (Prasad et al. 1998). Application of recommended doses of fertilizers (RDF), the major, secondary and micronutrients, to pigeonpea is essential for higher yield under rainfed conditions. To combat the above

stated low yield, an experiment was designed to find out the influence of liming and micronutrients on production of pigeonpea in Alfisols under rainfed conditions.

Materials and Methods

A field experiment was conducted during three consecutive kharif seasons of 2011-12, 2012-13 and 2013-14 at the research farm of College of Agriculture, Lembucherra, Tripura situated between 22°57' N latitude and 91°09' E longitude. The soil of the experimental site was sandy loam having pH of 5.4, organic carbon (0.79 gm kg⁻¹), available nitrogen of 260.0 kg ha⁻¹, available phosphorus of 19.0 kg ha⁻¹, available potash of 123.0 kg ha⁻¹. The experiment was carried out during the kharif seasons where the climate of hilly zone is sub-tropical in nature with distinctive characteristics of high rainfall, high humidity and a prolonged winter (Fig-1). The treatments comprised two levels of Lime (150 and 200 kg ha⁻¹) in main plot A and two levels of molybdenum seed treatment (0 and 4g/kg of seed) in the main plot B and 4 treatments, viz 0% of RDF ha⁻¹, 50% of RDF ha⁻¹, 75% of RDF ha⁻¹ and 100% of RDF ha⁻¹ (Recommended dose @ 20:60:40 of NPK). The treatments were replicated thrice in split-split plot design. The plot size was 5.8 m×4.2 m. Pigeon pea variety 'UPAS-120' was grown during mid June keeping seed rate of 15 kg ha⁻¹. Lime as per treatment was applied 21 days before sowing of pigeonpea. Molybdenum in the form of sodium molybdate was applied as seed treatment @ 4gm molybdenum kg⁻¹ of seed. The seed treatment was done in solution of sodium molybdate for four hours before sowing and then seeds spread over gunny bag for two hours for leaching the solution from the seed. The crop was harvested in February in first year and January in second year and third year respectively. Fertilizers were applied in the form of urea, single super phosphate and murate of potash, respectively. Half of the nitrogenous fertilizer and entire dose of P₂O₅ and K₂O were

applied treatment-wise at the time of land preparation and the rest half of nitrogen were top dressed at 60 days after sowing (DAS). The data collected from the field and laboratory experiments were subjected to statistical analysis appropriate to the design and the treatment variations were tested for significance by F test (Gomez and Gomez, 1983). For determination of critical differences at 5% level of significance, Fisher and Yates (1963) tables were consulted. The economics of growth and yield of pigeon pea as influenced by the liming, molybdenum seed treatment and levels of recommended dose were calculated. Prices of the produce were taken as per the minimum support price, Rs 4350/- per quintal for pigeon pea grain and Rs. 200/- per quintal stick (alternative to fire wood). On the basis of that benefit cost ratio were calculated.

Results and discussion

Growth and flowering characters

In general, plant height increased with advancement in age of crop upto 120-130 DAS. Pooled data showed that plant height and primary branches was non-significantly affected by liming for the three years at all the stages of plant growth. Non-significantly higher plant height was observed in case of liming @ 150 kg ha⁻¹ than liming @ 200 kg ha⁻¹. The pooled data of three years showed that the plant height at harvest was 125.71 cm in case of liming @ 150 kg ha⁻¹ whereas 124.86 cm in case of liming @ 200 kg ha⁻¹ respectively (Table-1) which might be due to the reduced toxicity effect of aluminum and manganese after the application of lime whereas higher application leads to soil deficient in iron, copper and zinc with reduced availability of phosphorus and potassium. The results confirmed the findings of Das, 1996, Verma et al., 2004 and Sharma et al., 2010.

Among the molybdenum seed treatment the pooled data of three years reflects that plant height differs significantly where as primary branches differs non-significantly. At M₄ (Molybdenum seed treatment @ 4g kg⁻¹ seed) plant height were 10.54 % higher than M₀ (without seed treatment) and in case of primary branches M₄ were 8.41 % non-significantly higher than M₀. This increase was mainly due to molybdenum having important role in iron absorption with an essential component of major enzyme nitrate reductase in plants, carbohydrate metabolism and again a structural component of nitrogenase in all legume crops. These results are confirmed by the experiments of Verma et al., 2004 and Sharma et al., 2010.

Again, in case of different levels of substitution of recommended dose both plant height and primary branches differs significantly with the highest in R₁₀₀ (Full recommended dose @ 20: 60: 40) for plant height but primary branches showed higher values in R₇₅ (75% of RDF ha⁻¹). From the pooled data, plant height and primary branches highest values are 139.65 cm and 10.72 respectively which might be due to greater availability and synchronous supply of plant nutrients throughout the growth period. R₀ (untreated) attained the lowest values. Reduction in recommended dose of fertilizer beyond 75% resulted in significantly lower yields. Slow organic matter decomposition through changes in nutrient mineralization/immobilization improved the soil fertility and the potential nutrient supply to the growing cultivated crops (De and Bandyopadhyay, 2013). The results are in confirmatory of the findings by Sharma et al. 2007 and De et al., 2009.

From pooled data of three years it is depicted that days to 1st flowering and 50% flowering (days) were found to be differs non-significantly for liming, molybdenum seed treatment and different levels of recommended dose. Increase in flower

numbers, pod set improvement, and reduction in days to flowering are influenced by Mo (Prasad et al. 1998).

Yield attributing characters

The influence of liming, molybdenum seed treatment and different levels of recommended dose on no. of pods per plant, no. of seed per pod and 100 seed weight of maize was showed in the pooled data presented in the table 2. As regards liming, the mean maximum values of pods plant⁻¹, seed pod⁻¹ and 100 seed weight were 113.07 and 3.54 in L₁₅₀ (Liming @ 150 Kg ha⁻¹) and 7.85 g in L₂₀₀ (Liming @ 200 Kg ha⁻¹) which are 6.62 and 1.14 % higher than L₂₀₀ and -0.38% higher than L₁₅₀ respectively. This might be due to poor effect of sesquioxides after liming. The values of no. of seed pod⁻¹ and 100 seed weight varies non-significantly indicating that lime dose from 150 to 200 Kg ha⁻¹ had not reflected on the yield (Das, 1996 and Sharma et al., 2010).

There was significant difference between M₄ (molybdenum seed treatment@ 4 g Kg⁻¹) and M₀ (untreated) treatments in case of pods plant⁻¹. From the pooled data M₄ showed maximum mean values of 116.02, 3.58 and 8.10 g of pods plant⁻¹, seeds pod⁻¹ and 100 seed weight respectively. M₄ treatment yielded 12.5, 3.46 and 7.00% than M₀ and the reason behind it was mainly due to molybdenum having important role in plants with structural component of nitrogenase enzyme. Yield increase in these treatments may be the result of inhibition in flower and pod abscission, improvement in morpho-physiological characters in addition to higher pods per plant. Velayutham et al. (2003) and Reddy et al., (2007) confirmed the reports.

Again, in case of different levels of substitution of recommended dose both seed pod⁻¹ and 100 seed weight differs significantly with highest in R₁₀₀ (100% of RDF) but pods per plant differs significantly having highest in R₇₅ (75% of RDF). From the pooled data values having highest recorded are 118.73 in pods plant⁻¹, 3.75 in seeds pod⁻¹ and 8.69 g in 100 seed weight which is due to synchronous supply of plant nutrients throughout the growth period. The lowest being recorded with R₀ (untreated). The results are in confirmatory of the findings by De et al., 2009 and Sharma et al. 2007.

Yield characters

As per the pooled data (Table-3) of three years, grain yield and stick yield attained non-significant values in case of liming. L₂₀₀ (Liming @ of 200 Kg ha⁻¹) being the highest value of 1519.50 Kg ha⁻¹ of grain and 4008.40 Kg ha⁻¹ with stick yield under L₁₅₀. This might be due to increased values in pods plant⁻¹, seeds pod⁻¹ and 100 test weight. L₂₀₀ had 1.00% and L₁₅₀ by 2.51% higher than L₁₅₀ and L₂₀₀ in case of grain yield and stick yield respectively. Results were confirmed by the findings of De and Bandyopadhyay, 2013.

Higher values under molybdenum seed treatment also depicts the same reason of increased values under primary branches and yield attributing characters (Table-3). M₄ are significantly 11.51 and 11.10 % higher than M₀ (untreated). The results are confirmed by the findings of Sharma et al., (2010)

Again in case of different levels of recommended dose substitution R₁₀₀ showed better than R₇₅ followed by R₅₀ and R₀. They differ significantly from R₁₀₀ over R₀ by 87.11 and 66.58 % in case of grain yield and stick yield keeping the reason behind it the same as earlier one. Confirmations are obtained from the results of findings by Sharma et al., 2010 and De and Bandyopadhyay, 2013.

Table 1. Effect of liming, molybdenum seed treatment and different levels of recommended doses on growth and flowering characters of pigeon pea (Pooled over 3 years)

Treatments	Growth and flowering characters				
	Plant (cm)	Height	Primary branches	Days to 1 st flowering (days)	Days to 50% flowering (days)
Liming (L)					
L ₁₅₀	125.71		8.86	65	83
L ₂₀₀	124.86		9.22	68	84
S.E. ±	0.96		0.14	0.94	0.94
C.D (p=0.05)	N.S		N.S	N.S	N.S
Molybdenum (M) seed treated					
M ₄	131.86		9.41	66	84
M ₀	119.29		8.68	64	83
S.E. ±	0.47		0.23	0.50	0.50
C.D. (p=0.05)	1.83		N.S	N.S	N.S
Levels of Recommended Dose (R)					
R ₀	104.40		6.52	67	87
R ₅₀	122.50		8.92	66	83
R ₇₅	134.60		10.72	66	82
R ₁₀₀	139.65		10.01	66	83
S.E. ±	2.08		0.80	2.09	2.08
C.D. (p=0.05)	6.05		2.34	N.S	N.S

L₁₅₀ =Lime@150 Kg/ha, L₂₀₀ = Lime @ 200 kg/ha, M₄ = Molybdenum seed treatment @ 4g/kg of seed, M₀ = Molybdenum seed treatment @ 0g/kg of seed, R₀ =0% of RDF/ha, R₅₀ =50% of RDF/ha, R₇₅ =75% of RDF/ha and R₁₀₀ =100% of RDF/ha (RDF=Recommended dose @ 20:60:40 of NPK).

Table 2. Effect of liming, molybdenum seed treatment and different levels of recommended doses on yield attributing characters of pigeon pea (Pooled over 3 years)

Treatments	Yield attributing characters		
	No. of pods/plant	No. of seed/pod	100 seed weight (g)
Liming (L)			
L ₁₅₀	113.07	3.54	7.82
L ₂₀₀	106.05	3.50	7.85
S.E. ±	0.96	0.03	0.10
C.D (p=0.05)	5.86	N.S	N.S
Molybdenum (M) seed treated			
M ₄	116.02	3.58	8.10
M ₀	103.10	3.46	7.57
S.E. ±	0.47	0.22	0.27
C.D. (p=0.05)	1.83	N.S	N.S
Levels of Recommended Dose (R)			
R ₀	86.42	3.08	6.77
R ₅₀	121.42	3.58	7.98
R ₇₅	118.73	3.67	7.89
R ₁₀₀	111.67	3.75	8.69
S.E. ±	2.08	0.47	0.56
C.D. (p=0.05)	6.06	N.S	N.S

L₁₅₀ =Lime@150 Kg/ha, L₂₀₀ = Lime @ 200 kg/ha, M₄ = Molybdenum seed treatment @ 4g/kg of seed, M₀ = Molybdenum seed treatment @ 0g/kg of seed, R₀ =0% of RDF/ha, R₅₀ =50% of RDF/ha, R₇₅ =75% of RDF/ha and R₁₀₀ =100% of RDF/ha (RDF=Recommended dose @ 20:60:40 of NPK).

Table 3. Effect of liming, molybdenum seed treatment and different levels of recommended doses on yield characters of pigeon pea (Pooled over 3 years)

Treatments	Yield characters		
	Grain Yield (Kg/ha)	Stick yield (Kg/ha)	Harvest Index
Liming (L)			
L ₁₅₀	1504.40	4008.40	27.36
L ₂₀₀	1519.50	3910.20	27.86
S.E. ±	17.97	53.25	
C.D (p=0.05)	N.S	N.S	
Molybdenum (M) seed treated			
M ₄	1594.20	4167.60	27.73
M ₀	1429.70	3751.10	27.50
S.E. ±	5.75	20.32	
C.D. (p=0.05)	22.58	79.79	
Levels of Recommended Dose (R)			
R ₀	964.60	2890.90	24.96
R ₅₀	1539.00	4244.70	26.63
R ₇₅	1739.30	3886.00	31.53
R ₁₀₀	1804.90	4815.60	27.33
S.E. ±	60.77	210.95	
C.D. (p=0.05)	177.37	615.71	

L₁₅₀ =Lime@ 150 Kg/ha, L₂₀₀ = Lime @ 200 kg/ha, M₄ = Molybdenum seed treatment @ 4g/kg of seed, M₀ = Molybdenum seed treatment @ 0g/kg of seed, R₀ =0% of RDF/ha, R₅₀ =50% of RDF/ha, R₇₅ =75% of RDF/ha and R₁₀₀ =100% of RDF/ha (RDF=Recommended dose @ 20:60:40 of NPK).

Table 4. Effect of liming, molybdenum seed treatment and different levels of recommended doses on economics of pigeon pea (Pooled over 3 years)

Treatment	Grain yield (qha ⁻¹)	Stalk yield (qha ⁻¹)	Value of Grain yield (Rs.)	Value of Stalk yield (Rs.)	Gross Return (Rs.)	Total Cost (COST C)(Rs.)	NET RETURN (Rs.)	Per Day Return (Rs.)	B:C Ratio	
L ₁₅₀	M ₄ R ₀	9.96	29.05	43363.85	5811.53	49175.37	18720.00	30455.37	253.79	1.63
	M ₄ R ₅₀	14.08	39.50	61248.00	7901.86	69149.86	19470.00	49679.86	414.00	2.55
	M ₄ R ₇₅	19.85	45.11	86369.25	9022.84	95392.09	19970.00	75422.09	628.52	3.78
	M ₄ R ₁₀₀	20.92	59.25	91038.54	11851.16	102889.70	20220.00	82669.70	688.91	4.09
	M ₀ R ₀	9.88	28.89	43006.28	5778.31	48784.58	18000.00	30784.58	256.54	1.71
	M ₀ R ₅₀	13.21	37.85	57477.86	7570.78	65048.64	18750.00	46298.64	385.82	2.47
	M ₀ R ₇₅	16.00	35.13	69633.93	7027.83	76661.76	19200.00	57461.76	478.85	2.99
	M ₀ R ₁₀₀	16.41	45.85	71401.34	9170.88	80572.21	19500.00	61072.21	508.94	3.13
L ₂₀₀	M ₄ R ₀	10.10	29.58	43935.00	5917.84	49852.84	19720.00	30132.84	251.11	1.53
	M ₄ R ₅₀	18.57	48.86	80789.51	9773.74	90563.25	20470.00	70093.25	584.11	3.42
	M ₄ R ₇₅	16.56	38.15	72055.58	7630.08	79685.66	20920.00	58765.66	489.71	2.81
	M ₄ R ₁₀₀	17.47	43.85	75994.50	8771.89	84766.39	21280.00	63486.39	529.05	2.98
	M ₀ R ₀	8.63	28.09	37540.50	5619.89	43160.39	19000.00	24160.39	201.34	1.27
	M ₀ R ₅₀	15.69	43.55	68270.64	8711.22	76981.86	19750.00	57231.86	476.93	2.90
	M ₀ R ₇₅	17.14	37.03	74571.62	7407.30	81978.91	20200.00	61778.91	514.82	3.06
	M ₀ R ₁₀₀	17.38	43.65	75623.01	8731.17	84354.18	20560.00	63794.18	531.62	3.10

L₁₅₀ =Lime@ 150 Kg/ha, L₂₀₀ = Lime @ 200 kg/ha, M₄ = Molybdenum seed treatment @ 4g/kg of seed, M₀ = Molybdenum seed treatment @ 0g/kg of seed, R₀ =0% of RDF/ha, R₅₀ =50% of RDF/ha, R₇₅ =75% of RDF/ha and R₁₀₀ =100% of RDF/ha (RDF=Recommended dose @ 20:60:40 of NPK).

MSP Recommended by CACP=Rs. 4350 q⁻¹

Value of Stalk yield= Rs. 200 q⁻¹

Cost of Lime @ Rs. 12 kg⁻¹,

Molybdenum @ Rs. 12 g⁻¹

Urea @ Rs. 10 kg⁻¹,

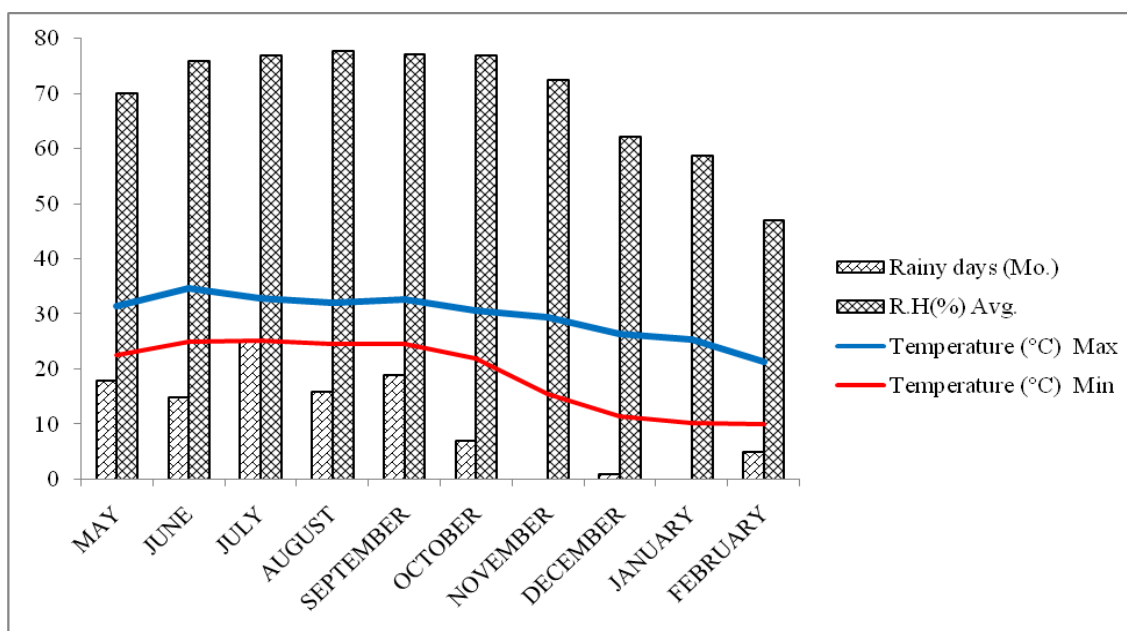
SSP @ Rs. 7kg⁻¹,

MOP @ Rs. 15 kg⁻¹.

#All the above prices are considered to be average of 3 years.

Table 5: Path analysis of characters due to the effect of liming, molybdenum seed treatment and different levels of recommended doses on economics of pigeon pea (Pooled over 3 years)

	Plant Height	Primary Branches	Pods /Plant	No. Of Seed/Pod	100 Seed Weight	Stick Yield	Grain Yield
Plant Height	1.000	0.999	-0.061	0.045	-0.069	-0.044	-0.077
Primary Branches		1.000	-0.067	0.034	-0.073	-0.068	-0.099
Pods/ Plant			1.000	0.969	-0.007	-0.063	-0.095
No. Of Seed/Pod				1.000	0.087	0.126	0.120
100Seed Weight					1.000	-0.060	0.526
Stick Yield						1.000	0.816
Grain Yield							1.000

**Fig 1. Mean average weather condition of three years****Economic Analysis**

It was observed that by the application of lime @ 150 kg ha⁻¹, highest grain yield was obtained 20.93 q ha⁻¹ with net return Rs. 82669.70 ha⁻¹ and return per rupee was 4.09 whereas by the application of more lime i.e. 200 kg ha⁻¹, highest grain yield was recorded 18.57 q ha⁻¹ with net return Rs. 70093.25 ha⁻¹ due to higher cost of cultivation (Rs. 20,470.00 ha⁻¹) compare to the L₁₅₀ treatments and return per rupee was recorded 3.42. These results are confirmed with the findings of Sharma et al (2010). Puste and Jana (1995) reported that the yield attributes and seed yield of pigeonpea varieties were significantly influenced by phosphorus and zinc application with a maximum benefit-cost ratio of 4.12.

The findings were revealed that the application of molybdenum @4 g kg⁻¹ of seed as micronutrient was widely significant as compare to M₀ treatments. The result observed that in M₄ treatments 20.92 q ha⁻¹ followed by 19.85 q ha⁻¹ and 18.57 q ha⁻¹ with per day return of Rs. 688.91, 628.52 and 584.11 respectively. Yadav et al. (1997) reported that with the application of 100% recommended fertilizer, sole pigeon pea gave a grain yield of 2.12 t ha⁻¹ with net returns of Rs.12,491 per hectare and a benefit-cost ratio of 2.94. These results corroborated the findings of Ramakrishna (2005).

The application of 100% RDF, highest yield was observed as 20.92 q ha⁻¹ whereas with 75% RDF 19.85 q ha⁻¹, 50 % RDF 18.57 q ha⁻¹ and with 0% RDF 10.10 q ha⁻¹ along with per day

return Rs. 688.91, Rs. 628.52, Rs. 584.11 and Rs. 251.11 respectively.

Path analysis

As per the correlation matrix among the characters (table 5) it clearly depicts that plant height, primary branches and pods per plant negatively correlates with 100 seed weight, stick yield and grain yield. It also shows that no. of seed per pod, 100 seed weight and stick yield are positively correlated with grain yield. Again it can be concluded from the matrix that pods per plant are not directly involved in higher grain yield.

Conclusion

By virtue of its resilience in rainfed condition, pigeon pea will play a greater role in our agriculture. Though the combination of 150 Kg/ha of lime and seed treatment with molybdenum @ 4g/kg of seed and 100% of recommended dose showed higher B: C ratio but it is achieved with intensive use of chemical fertilizer deteriorating the soil health and increasing the production cost. Further investigation reflect that by the use of 75% RDF per day return was only Rs. 60.39 less compare to 100% RDF with saving the cost of 25% RDF. So, from overall and particularly economic point of view, we have come to conclusion that the treatment L₁₅₀M₄R₇₅ (150 Kg/ha lime with 4g/kg of molybdenum seed treatment and 75% of recommended dose) can be suggested for good response of pigeonpea under rainfed conditions in Alfisols.

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