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Effect of Different Tillage, Nutrient Management Practices and Foliar Application of KNO_3 and Borax on Yield Attributes and Yield of Pigeonpea [*Cajanus cajan* (L.)]

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Abstract

Background: Pigeonpea productivity is low as it is grown in low fertility soils under inadequate fertilizer applications that has led to emergence of several nutrient deficiencies. The lower yield of pigeonpea is not only due to its cultivation in sub marginal lands, but also due to poor management, flower dropping and subsoil compaction that leads to restricted water infiltration, there by bringing many chemical and biological changes which affect the plant growth. It is important to adopt appropriate tillage practices in combination with proper nutrient management practices that avoid degradation of soil structure, reduce flower drop, maintain crop yield as well as ecosystem stability.

Methods: A two year field experiment was conducted during two consecutive *kharif* seasons of 2019-20 and 2020-21 at S.V. Agricultural College, Tirupati Andhra Pradesh to study the effect of different tillage, nutrient management practices and foliar application of KNO_3 and borax on yield attributes and yield of pigeonpea [*Cajanus cajan* (L.)] in a split-split plot design, consisting of three tillage practices in main plots, three nutrient levels in sub plots and three foliar sprays in sub-sub plots on sandy loam soil which was low in available nitrogen, medium in available phosphorus and available potassium.

Result: Our investigations concluded that among combinations higher number of pod bearing branches plant^{-1}, number of pods branch^{-1}, total number of pods plant^{-1}, number of seeds pod^{-1}, hundred seed weight and seed yield of pegonpea was recorded with vertical tillage with subsoiler upto 60 cm deep at 1 m interval coupled with application of 125% RDF and with foliar application of KNO_3 1% twice with 15 days interval at 50 per cent flowering stage.

Key words: Foliar sprays, Nutrient levels, Tillage, Yield attributes, Yield of pigeonpea.

Introduction

Pulses form an important part for nutritional security, sustainable crop production and occupy a unique position in Indian agriculture, besides being rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in sustainable agriculture (Balusamy and Meyyazhagan, 2000). Pigeonpea has special morphological characters with respect to deep rooting and drought tolerance that have made adaptable for growing in wide range of unfavourable conditions with uncertain rainfall and varied soil depth. It is the second most important pulse crop of India, which occupies an area of 4.82 million hectares with production of 3.88 million tonnes and average productivity of 804 kg ha^{-1}. In Andhra Pradesh, pigeonpea is grown under rainfed conditions to an extent of 2.23 lakh hectares with an annual production of 1.16 lakh tonnes and productivity of 486 kg ha^{-1} (Directorate of Economics and Statistics, Govt. of A.P, 2019-20).

The lower productivity of pigeonpea is not only due to its cultivation in sub marginal lands under energy starving situations, low fertility and inadequate fertilizer applications, but also due to its high elasticity, indeterminate growth habit, poor source-sink relationship, poor translocation efficiency at later stages of crop growth, flower dropping and subsoil compaction that leads to restricted water infiltration, there by bringing many chemical and biological changes which affect the plant growth and regular depletion of nutrient resources of soils has led to emergence of several nutrient deficiencies (Ware *et al*., 2018). Among them soil tillage coupled with balanced fertilizer application and foliar nutrition are the key factors determining the yield.

Tillage and fertilizer management play essential roles in both the nutrient and soil moisture dynamics of soil-plant systems. The effect of tillage on the soil physical properties are often soil and site specific and they depend primarily on the cropping system, antecedent soil characteristics and

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available clay minerals. Studies conducted in several plants showed that vertical tillage with subsoiler could improve the soil physical properties, particularly the infiltration, bulk density, water retention, structure and aggregate stability. Subsoil tillage is one of the most effective ways to break up a plough pan, loosening the soil and deepening the topsoil without inverting it and increasing soil permeability. It can also play an important role in promoting water storage in the soil, adjusting the proportion of solid, liquid and gas of soil, improving the structure and characteristics of topsoil and improving the ecological environment for root development and root activities that enhance the anti-stress capacity of plants (Cai *et al.,* 2014, Priya, 2017 and Ramana *et al*., 2015).

As such, there is immense scope for augmenting its yield through balanced application of nutrients. There is a need to study whether there is any scope for improving its productivity with higher rates of nutrient application. Hence, its performance has been tested at three levels of nitrogen, phosphorus and potassium application in the present investigation.

Among the methods of fertilizer application, foliar nutrition is recognized as an important one, since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy, rapid utilization and supplying nutrient instantly to crop. The prominent effect of foliar application of nutrients at 50 per cent flowering stage was exert important consequence on physiological processes in plants like ion transport, translocation of carbohydrates, proteins and their storage during seed formation and reduction in flower shed and flower drop percentage (Sarkar and Malick, 2009).

Pigeonpea responses to tillage, nutrients and foliar application of nutrients reportedly vary considerably, depending on soil, weather and various other factors. To this end, this study was conducted to evaluate and identify efficient tillage, fertilizer management practices and foliar sprays to attain sustainable yields.

MATERIALS AND METHODS

A field experiment was conducted at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University andhra Pradesh during two consecutive *kharif* seasons of 2019-20 and 2020-21 to study the effect of different tillage, nutrient management practices and foliar application of KNO_3 and borax on yield attributes and yield of pigeonpea [*Cajanus cajan* (L.)]. The soil of the experimental field was sandy loam in texture, low in available N, medium in available P and available K. Pigeonpea variety LRG -52 was used for experimentation. The experiment was laid in split-split design with three tillage practices (T_1: Conventional tillage with tractor drawn cultivator, T_2: Ploughing with duck foot cultivator upto a depth of 30 cm and T_3: Vertical tillage with subsoiler upto 60 cm deep at 1.0 m interval) in main plots, three nutrient levels (N_1: 75% RDF, N_2: 100% RDF (20-50-00 kg ha^{-1}) and N_3: 125% RDF) in subplots and three foliar sprays (F_1: Control (No spray) F_2: Borax 0.1% F_3: KNO_3 1%) in sub-sub plots. Three nutrient levels were applied to sub plots as per the prescribed treatments assigned. Entire quantities of N, P_2O_5 and K_2O were applied by placement method at the time of sowing and first foliar spray of Borax 0.1% and KNO_3 1% was done at 50 per cent flowering stage and second spray at 15 days after the first spray.

RESULTS AND DISCUSSION

Yield attributes

The results obtained from present study showed significant variation in yield attributes of pigeonpea among different tillage, nutrient management practices and foliar sprays.

The highest number of pod bearing branches plant^{-1}, number of pods branch^{-1} and plant^{-1} with T_3 which was significantly higher than the T_2 and T_1 which recorded the lower number of pod bearing branches, number of pods branch^{-1} and plant^{-1} in the order of descent during both the years (Table 1).

More number yield attributes was observed in T_3 due to better translocation of photosynthates from source to developing pods on account of overall improvement in vegetative growth which favourably influenced the flowering and fruiting in pigeonpea grown under vertical tillage (Table 2). In addition, the favourable soil conditions *viz*., more availability of nutrients and moisture was recorded with T_3 tillage practices. The results supported the findings of Ramana *et al.* (2015), Mathukia *et al.* (2015) and Priya (2017), Wang *et al.* (2019), Liang *et al.* (2019) and Preetham *et al.* (2020). The lower number of yield parameters were registered with T_1 due to late flowering coupled with poor availability of nutrients and moisture (Ramana *et al*., 2015 and Priya 2017).

Among the nutrient doses, maximum number of pod bearing branches plant^{-1}, number pods branch^{-1} and plant^{-1} was recorded with N_3 which was significantly superior to N_2 and N_1 (Table 1). The highest number of yield attributes can be attributed to an adequate and continuous availability of nutrients to plants which resulted in better partitioning of photosynthates and synchronized early flowering which facilitated for producing more number of these parameters. These results are in accordance with the findings of Nagamani (2015), Das *et al.* (2016), Dalai *et al.* (2018), Beniwal and Tomer, (2019) and Divyavani *et al.* (2020). The lowest number of these parameters were recorded in T_1 due to late flowering coupled with poor availability of nutrients and moisture (Priya 2017 and Ramana *et al*., 2015).

Among foliar applications, F_3 resulted in higher number of pod bearing branches plant^{-1}, pods branch^{-1} and plant^{-1} which was however comparable with F_2 and significantly superior to F_1 during both the years of study (Table 1). The better performance of foliar spray applications might be due to meeting the nutrient demand of the crop at the critical stage by providing nitrogen and potassium which delays the synthesis of abscisic acid, promotes cytokinin activity causes

Table 1: Number of pod bearing branches plant-1, number of pods branch^{-1} and plant^{-1} of redgram as influenced by tillage and nutrient management practices during 2019-20 and 2020-21.

Treatments	No. of pod bearing branches plant^{-1}		Pooled	No. of pods branch^{-1}		Pooled	Total no. of pods plant^{-1}		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots: Tillage practices (T) (3)									
T_1- Conventional tillage with tractor drawn cultivator	12.10	12.64	12.37	13.33	10.14	11.74	169	134	152
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	12.35	13.58	12.97	14.43	11.11	12.77	183	155	169
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	14.67	15.98	15.33	17.00	12.98	14.99	259	214	237
SEm±	0.461	0.481	0.471	0.586	0.404	0.495	14.5	11.3	12.9
CD (P= 0.05)	1.81	1.89	1.85	2.30	1.58	1.94	57	44	51
Sub plots: Nutrient management practices (N) (3)									
N_1- 75% RDF	11.99	12.93	12.46	13.72	10.29	12.01	170	138	154
N_2- 100% RDF	12.61	13.60	13.11	14.43	11.41	12.92	188	160	174
N_3- 125% RDF	14.52	15.67	15.10	16.61	12.53	14.57	252	205	229
SEm±	0.408	0.446	0.427	0.447	0.332	0.390	11.7	10.1	10.9
CD (P= 0.05)	1.26	1.37	1.315	1.38	1.02	1.200	36	31	34
Sub sub plots: Foliar sprays (F) (3)									
F_1- Control	12.31	13.28	12.80	13.84	10.55	12.20	178	147	163
F_2- Borax 0.1%	12.97	13.99	13.48	14.89	11.39	13.14	202	167	185
F_3- KNO_3 -1.0%	13.84	14.93	14.39	16.04	12.30	14.17	230	190	210
SEm±	0.369	0.393	0.381	0.415	0.313	0.364	10.8	9.3	10.1
CD (P= 0.05)	1.06	1.13	6.720	1.19	0.90	1.045	31	27	29
Interaction									
T × N									
SEm±	0.706	0.772	0.739	0.774	0.575	0.675	20.2	17.5	18.8
CD (P= 0.05)	2.17	2.38	2.27	2.39	1.77	2.08	62	54	58
T × F									
SEm±	0.640	0.680	0.660	0.718	0.542	0.630	18.6	16.1	17.3
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F									
SEm±	0.640	0.680	0.660	0.718	0.542	0.630	18.6	16.1	17.3
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F									
SEm±	1.108	1.178	1.143	1.244	0.939	1.092	32.3	27.9	30.1
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

RDF- Recommended dose fertilizer *Significant at P 0.05; NS- Non Significant at P>0.05.

Table 2: Number of seeds pod^{-1}, hundred seed weight and seed yield (kg ha^{-1}) of redgram as influenced by tillage and nutrient management practices during 2019-20 and 2020-21.

Treatments	No. of seeds pod^{-1}		Pooled	100 seed weight (g)		Pooled	Seed yield		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots: Tillage practices (T) (3)									
T_1- Conventional tillage with tractor drawn cultivator	2.19	2.63	2.41	11.65	11.06	11.36	1210	1089	1149
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	2.86	3.44	3.15	12.02	11.31	11.67	1358	1223	1290
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	3.40	4.07	3.74	12.64	12.02	12.33	1614	1452	1533
SEm±	0.115	0.138	0.127	0.180	0.163	0.172	46.1	41.5	43.8
CD (P= 0.05)	0.45	0.54	0.50	0.71	0.64	0.68	181	163	172
Sub plots: Nutrient management practices (N) (3)									
N_1- 75% RDF	2.58	3.10	2.84	11.85	11.23	11.54	1281	1153	1217
N_2- 100% RDF	2.72	3.26	2.99	12.18	11.53	11.86	1346	1212	1279
N_3- 125% RDF	3.15	3.78	3.46	12.28	11.62	11.95	1555	1399	1477
SEm±	0.150	0.180	0.165	0.085	0.078	0.082	45.0	40.5	42.7
CD (P= 0.05)	0.46	0.55	0.51	0.26	0.24	0.25	139	125	132
Sub sub plots: Foliar sprays (F) (3)									
F_1- Control	2.11	2.53	2.32	11.84	11.21	11.53	1287	1158	1222
F_2- Borax 0.1%	2.78	3.34	3.06	12.13	11.49	11.81	1394	1254	1324
F_3- KNO_3 -1.0%	3.56	4.27	3.92	12.35	11.69	12.02	1502	1351	1426
SEm±	0.131	0.157	0.144	0.102	0.097	0.100	35.2	31.6	33.4
CD (P= 0.05)	0.37	0.45	0.41	0.29	0.28	0.29	101	91	96
Interaction									
T × N									
SEm±	0.260	0.312	0.286	0.146	0.135	0.141	77.1	70.1	74.0
CD (P= 0.05)	0.80	0.96	0.88	NS	NS	NS	240	216	228
T × F									
SEm±	0.226	0.271	0.249	0.176	0.167	0.172	60.8	54.7	57.8
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F									
SEm±	0.226	0.271	0.249	0.176	0.167	0.172	60.8	54.7	57.8
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F									
SEm±	0.392	0.469	0.431	0.176	0.290	0.233	105.4	94.9	100.1
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

RDF- Recommended dose fertilizer *Significant at P 0.05; NS- Non Significant at P>0.05.

high chlorophyll retention, photosynthetic activity in effective leaves for supply of current photosynthates from source to sink over longer period to plants and alters physiological and biochemical aspects enhances plant vigour and strengthens the stalk, further it has synergistic effect with phosphorus that resulted in more number yield attributes. Similar results were reported by Hiwale, (2015) and Jadhav *et al.* (2019).

Among the different tillage practices tried, maximum number of seeds pod^{-1} and hundred seed weight was registered with T_3 followed by T_2 and T_1 in the order of descent, during both the years (Table 2). Maximum number of seed pod^{-1} and hundred seed weight might be due to better channelization of more photosynthates from vegetative parts to developing seeds resulting in complete filling of the pods. The activities of key nitrogen metabolism, enzymes and intermediate products of nitrogen assimilation were significantly higher by subsoiling than the duck foot tillage and conventional tillage methods. Subsoiling tillage had a higher translocation and absorption of N after flowering from vegetative organs to pods increasing the number of seeds pod^{-1} and higher hundred seed weight by subsoiling producing bigger sized seeds. Similar results were in accordance with findings of Cai *et al.* (2014), Mathukia *et al.* (2014) and Liang *et al.* (2019).

Increase in the nutrient dose significantly increased the number of seeds pod^{-1} during both the years of study. N_3 recorded significantly higher number of seeds pod^{-1} of pigeonpea which was significantly superior to N_2 and N_1. The latter two treatments were comparable with each other. The highest number of seeds pod^{-1} and hundred seed weight which can be attributed to availability of balanced nutrients, which led to better translocation of assimilates to produce more number of seeds pod^{-1} and larger sized seeds that ultimately resulted in higher test weight and efficient utilization of growth resources. Number of seeds pod^{-1} was reduced with decreased fertilizer dose due to severe competition for growth resources and poor translocation of photosynthates from pod walls and other vegetative plant parts to developing pods. Similar results were also reported by Sharma *et al.* (2013) and Reddy *et al.* (2011). The lowest number of seeds pod^{-1} was observed with 75% RDF (N_1) due to poor source-sink relations.

Foliar application (F_3) registered maximum number of seeds pod^{-1} and hundred seed weight which was significantly superior to F_2 and F_1. The difference between latter two treatments was also significant.

Maximum number of seeds pod^{-1} and hundred seed weight (Table 2) was recorded with F_3 due to the higher availability of nutrients that was supplied through foliar feeding of KNO_3 which enhanced the number of floral buds, prevented the floral shedding and activate the biochemical functions in plants, enzyme activation, photosynthesis, cell division and translocation of photosynthates from source to sink that resulted in larger pod filling period leading to greater number of seeds pod^{-1}. Similar results were also reported earlier by Keerthi *et al.* (2015), Gorakshnath *et al.* (2016) and Vijayakumar *et al.* (2019). Control (No spray) (F_1) recorded lower number of seeds pod^{-1} due to poor partitioning efficiency of photosynthates from source to sink.

Yield

Various tillage practices, nutrient management practices and foliar sprays significantly influenced the seed yield of pigeonpea with unaltered trend during both the years as well as pooled. The highest seed yield of pigeonpea was recorded with T_3 and significantly superior to T_2 and T_1 which recorded lower seed yield (Table 2).

Higher seed yield of pigeonpea due to vertical tillage with subsoiler can be attributed to an improving soil environment by favorable soil physical conditions such as changes in soil bulk density, penetration resistance, moisture content, root proliferation, available N reserves and increase in the quantum of nutrient absorption due to better root development, improving nitrogen accumulation and translocation, amount of N mobilization in stem and sheath reflected in better development and expression of growth and yield components, better portioning of photosynthates to developing pods which inturn resulted in higher seed. Similar findings were reported by Priya *et al.* (2017), Feng *et al.* (2018) and Liang *et al.* (2019). Lower seed yield due to conventional tillage practice was attributed to compacted layer that was not loosened, the rooting of pigeonpea was shallower resulting in lower moisture and nutrient uptake and a more rapid depletion of moisture in the rooting zone. These results are in agreement with findings of those Jordan *et al.* (2008) and Barbosa *et al.* (1989).

Successive increase in fertilizer dose from 75% RDF to 125% RDF progressively increased the seed yield of pigeonpea with significant disparity among one another. N_3 recorded significantly highest seed yield followed by N_2 and N_1 in the order of descent (Table 2).

The highest seed yield was due to with higher nutrient dose increased supply of nutrients which inturn increased the multi role activities in plant and soil, rate of symbiotic N fixation, energy transformation and metabolic processes which resulted in maximum growth parameters, yield attributing characters and higher rate of photosynthesis that helped in the greater accumulation of carbohydrates, protein and their translocation to the reproductive organs which inturn resulted in greater translocation of photosynthates towards the sink development. The results are in close agreements with those of Singh *et al.* (2016), Ware *et al.* (2018), Nagamani *et al.* (2020), Tekule *et al.* (2020) and Ghule *et al.* (2021).

Maximum seed yield of pigeonpea was recorded with F_3 followed by F_2 and F_1 in the order of descent, with significant disparity between any two of the three foliar sprays tested.

Highest seed yield with foliar application of KNO_3 might be due to better transport of assimilates thereby better balanced supply with cation and anions of potassium, nitrate nitrogen respectively enhancing the each other nutrient availability at critical stages that could have induced more flowering, reduction in flower shedding, delayed the synthesis of abscisic acid and promoted cytokinin activity, activation of enzymes responsible for carbohydrates redistribution and increased transportation of photosynthates from source to sink and in later stages, more assimilates are produced than used in growth and development, excess assimilates are diverted to storage compounds resulting increased seed yield of pigeonpea. These results are in accordance with findings of Sarkar and Mallick, (2001), Shrikanth, (2008) and Tripathy *et al.* (2018), Vijayakumar *et al.* (2019), Laishram *et al.* (2020) and Ghule *et al* (2021).

CONCLUSION

From the present investigation it can be concluded that vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3) with application of 125% RDF (N_3) and foliar application of KNO_3-1% (F_3) twice at 50 per cent flowering stage of pigeonpea at 15 days interval resulted in better yield attributes and seed yield of pigeonpea.

Conflict of interest: None.

REFERENCES

Balusamy, M and Meyyazhagan, N. (2000). Foliar nutrition to pulse crop. Training Manual on Recent Advances in Pulses Production Technology, CASA, Tamil Nadu Agricultural University. 113-115.

Barbosa, L.R., Diaz, O and Barrer, R.G. (1989). Effects of deep tillage on soil properties, growth and yield of soybean in a compacted Ustochrept in santa Cruz, Bolivia. Soil and Tillage Research. 15: 51-63.

Beniwal, V. and Tomer, A. (2019). Effect of integrated nutrient management on growth parameters of black gram (*Vigna mungo* L.). International Journal of Current Microbiology and Applied Sciences. 8(6): 2045-2053.

Cai, H., Ma, W., Zhang, X., Ping, Jieqing, Yan, X., Liu, J., Jingchaouan, Wang, L and Ren, J. (2014). Effect of subsoil tillage depth on nutrient accumulation, root distribution and grain yield in spring maize. The Crop Journal. 2(5): 297-307.

Dalai, S., Evoor, S., Hanchinamani, C.N., Mulge, R., Mastiholi, A.B., Kukanoor, L and Kantharaju, V. (2018). Effect of different nutrient levels on yield components, nutrient uptake and post-harvest soil fertility status of dolichos bean. International Journal of Current Microbiology and Applied Sciences. 8(2): 187-195.

Das, A., Layeka, J., Ramkrushna, G.I., Rangappaa, K., Lal, R., Ghosh, D., Burhan, P.K., Choudhurya, U., Mandale, S., Ngangoma, B., Deya, U and Prakash, N. (2019). Effects of tillage and rice residue management practices on lentil root architecture, productivity and soil properties in India's Lower Himalayas. Soil and Tillage Research. 194-104.

Das, S.K. Mandale, S., Ngangoma, B. and Deya, U. (2016). Effect of phosphorus and sulphur on yield attributes, yield, nodulation and nutrient uptake of green gram [*Vigna radiata* (L.) wilczek]. Legume Research. 40(1): 138-143.

Directorate of Economics and Statistics. (2019-20). Planning department, Agricultural statistics at a glance. Government of Andhra Pradesh.

Divyavani, B.R., Ganesh, V. and Dhanuka, D. (2020. Effect of integrated nutrient management on growth and yield in black gram [*Vigna mungo* (L.) Hepper] under doon valley condition. Journal of Pharmacognosy and Phytochemistry. 9(5): 2928-2932.

Feng, X., Hao, Y., Latifmanesh, H., Lal, R., Cao, T., Guo, J., Deng, A., Song, Z and Zhang, W. (2018). Effects of subsoiling tillage on soil properties, maize root distribution and grain yield on mollisols of Northeastern China. Agronomy Journal. 110: 1607-1615.

Ghule, N.S., Bhosale, A.S., Shende, S.M and Gedam, V.B. (2020). Effect of fertilizer levels on yield, nutrient content and uptake of summer green gram (*Vigna radiata* L.). International Journal of Chemical Studies. 8(6): 1670-1673.

Gorakshnath, N.S. (2016). Effect of foliar application of micronutrients and potassium nitrate on growth and yield of chickpea (*Cicer arietinum* L.). M.Sc (Ag.), Thesis. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, India.

Hiwale, R. (2015). Effect of foliar application of potassium nitrate on yield, growth and quality of soybean (*Glycine max* (L.) Merrill. M.Sc. (Agri.) Thesis, Vasantrao Naik Marathwada Agril. University, Parbhani. India. International Journal of Agriculture Sciences. 7(5): 516-519.

Jadhav, U.B., Indulkar, B.S and Tistak, S.E. (2019). Effect of foliar application of nutrients on growth of soybean [*Glycine max* (L.) Merrill]. Bulletin of Environment, Pharmacology and Life Sciences. 8(4): 52-55.

Jordan, D.L., Barnes, J.S., Bogle, C.R., Naderman, G.C., Roberson, G.T and Johnson, P.D. (2001). Peanut response to tillage and fertilization. Agronomy Journal. 93: 1125-1130.

Jordan, D.L., Barnes, J.S., Corbett, T., Bogle, C.R., Johnson, P.D., Shew, B.B., Koenning, S.R., Ye, W. and Brandenburg, R.L. (2008). Crop response to rotation and tillage in peanut-based cropping systems. Agronomy Journal. 100(6): 1580-1586.

Keerthi, M.M., Babu, R., Joseph, M and Amutha, R. (2015). Optimizing plant geometry and nutrient management for grain yield and economics in irrigated greengram. American Journal of Plant Sciences. 6: 1144-1150.

Laishram, B., Singh, B.T., Kalpana, Merinda, A., Wangkheirakpam, Chongtham, K.S. and Singh, W.J. (2020). Effect of salicylic acid and potassium nitrate on growth and yield of lentil (*Lens culinaris* L.) under rainfed condition. International Journal of Current Microbiology and Applied Sciences. 9(11): 2779-2791.

Liang, Y.F., Khan, S., Ren, A., Lin, W., Anwar, S., Sun, M. and Gao, Z. (2019). Subsoiling and sowing time influence soil water content, nitrogen translocation and yield of dryland winter wheat. Agronomy. 9(37):2-15.

Mathukia, R.K, Khanpara, V.D and Polara, A.M. (2007). Effect of subsoiling, broad bed furrow and zinc fertilization on yield, quality and nutrient uptake by rainfed castor (*Ricinus communis* L.). Agricultural Science Digest. 27(2): 116-118.

Mathukia, R.K., Mathukia, P.R and Polara, A.M. (2015). Effect of preparatory tillage and mulch on productivity of rainfed pigeonpea [*Cajanus cajan* (L.) Millsp.]. Indian Journal of Dryland Agriculture Research and Development. 30(2): 58-61.

Nagamani, C. (2015). Agrotechniques for enhancing the productivity of *Rabi* redgram [*Cajanus cajan* (L.) millsp.] and study of carryover effect on yield of summer fodder. Ph.D thesis, ANGRAU, Lam, Guntur.

Nagamani, C., Sumathi, V and Reddy, G.P. Reddy. (2020). Yield and nutrient uptake of pigeonpea [*Cajanus cajan* (L.)] as influenced by sowing window, nutrient dose and foliar sprays. Agricultural Science Digest. 40(2): 149-153.

Preetham, R., Kumar,K.A., Srinivas, A., Rao,A.M and Ramprakash, T. (2020). Effect of Nutrient Management on Dry Matter Production and Nutrient Uptake of Hyacinth bean in Baby corn (*Zea mays* L.)- Hyacinth bean (*Lablab purpureus* var. typicus) Cropping System. International Journal of Bio-resource and Stress Management. 4(8):125-131.

Priya, B. (2017). Influence of vertical tillage and nutrient management on moisture conservation and performance of groundnut-greengram sequence. Ph.D (Ag.). Thesis, ANGRAU, Lam, Guntur.

Ramana, C., Sudhakar, P., Krishna Reddy, G., NagaMadhuri, K.V., Prashanthi, T., Lavanya Kumari, P., Giridhara Krishna, T and Hemasri, A. (2015). Economic effect of mechanical intervention through sub-soiling on growth and yield of rainfed pigeonpea (*Cajanus cajan*). Indian Journal of Agricultural Sciences. 85(7): 873-876.

Reddy, S.T., Reddy, D.S and Reddy, G.P. (2011). Influence of fertilizer management practices on growth, yield and quality of export oriented groundnut [*Arachis hypogeae* (L.)]. The Andhra Agricultural Journal. 58(1): 105-109.

Sarkar, R.K and Malik, G.C. (2001). Effect of foliar spray of potassium nitrate and calcium nitrate on grasspea (*Lathyrus sativus* L.) grown in rice fallows. Lathyrus Lathyrism Newsletter. 2: 47-48.

Sarkar, R.K, Mallik, A. and Pal P.K (2006). Effect of pre-sowing seed treatment and foliar spray of nitrate salts on growth and yield of green gram (*Vigna radiata* L.). Indian Journal of Agricultural Sciences. 76(1): 62-65.

Sharma, S., Jat, N.L., Shuvran, A.C., Choudhary, S., Puniya, M.M and Jeetarwal, R.L. (2013). Effect of fertility levels and bio-fertilizers on yield and economics of groundnut. Annuals of Agricultural Research New Series. 34(4): 353-356.

Shrikanth, Merwade, M.N., Channaveerswami, A.S., Tirakannanavar, S., Mallapur, C.P and Hosamani, R.M. (2008). Effect of spacings and fertilizer levels on crop growth and seed yield in lablab bean (*Lablab purpureus* L.). Karnataka Journal of Agricultural Sciences. 21(3): 440-443.

Singh, S.K., Kumari, N., Karmakar, S., Puran, A.N and Pankaj, S.C. (2016). Productivity, economics and nutrient uptake of hybrid pigeonpea as influenced by different fertility and lime levels under rainfed conditions. Environment and Ecology. 34 (2A): 726-729.

Tekulu, K., Taye, G. and Assefa, D. (2020). Effect of starter nitrogen and phosphorus fertilizer rates on yield and yield components, grain protein content of groundnut (*Arachis hypogaea* L.) and residual soil nitrogen content in a semiarid north Ethiopia. Heliyon. 6: 1-12.

Tripathy, S.K., Mohapatra, S., Mohanty, A.K., Panigrahy, N., Lenka, S., Panda, G.S and Nayak, B.R. (2018). Effect of Nitrate of Potassium and Calcium on Grain Filling and Yield of Hybrid Rice. Indian Journal of Hill Farming. 31(1): 41-44.

Vijayakumar, S., Kumar, D., Shivay, Y.S., Anand, A., Saravanane, P. and Singh, N. (2019). Potassium fertilization for enhancing yield attributes, yield and economics of wheat (*Triticum aestivum*). Indian Journal of Agronomy. 64(2): 226-231.

Wang, S., Guo, L., Zhou, P., Wang, X., Shen, Y., Han, H., Ning, T. and Han, K. (2019). Effect of subsoiling depth on soil physical properties and summer maize (*Zea mays* L.) yield. Plant, Soil and Environment. 65(3): 131-137.

Ware, B.P., Suryavanshi, V.P and Dambale, A.S. (2018). Impact of topping and fertilizers levels on growth, yield and economics of pigeonpea (*Cajanus cajan* L.). Journal of Agricultural Research and Technology. 43(2): 410-413.