Environment and Ecology 41 (1B) : 480—485, January–March 2023
ISSN 0970-0420

Effect of Plant Growth Regulators in Conjunction with Insecticides on the Productivity of Pigeon Pea [*Cajanus cajan* (L.) Millsp.]

Satya Narayan Meena, Pratap Singh, L. K. Meena, S. L. Yadav, Uditi Dhakad, S. N. Regar, B. S. Meena

Received 3 November 2022, Accepted 26 December 2022, Published on 6 March 2023

ABSTRACT

Pigeon pea is a long duration crop and initially having poor growth rate as compared to other pulses which may cause poor competition against weed population and less resistant against insect pest and disease. The large proportion of uncovered land area may cause development of insect pest on weedy plants which results poor crop growth subsequently. Additional canopy of crop at early stage through the application of insecticide and growth regulators may surpass the insect population and boost the yield. Keeping above in view a field experiment with ten treatments was conducted to find out compatibility between insecticides and growth regulators for enhancing productivity and profitability of pigeon pea. Results revealed that application of rynaxipyr 18.5 EC @ 100 g a.i./ha + NAA 40 ppm at flowering followed by Indoxacarb 15.8 EC @ 375ml ha^{-1} at 15 days later (T7) recorded significantly higher plant height (192.6 cm), branches (19.6 $plant^{-1}$), pods (203.9 $plant^{-1}$), seeds (4.2 pod^{-1}), test weight (104.8 g), grain yield (1550 kg ha^{-1}), net return (₹63059 ha^{-1}) and B: C ratio (3.16) as compared to control, T1, T2, T3, T4 and T5 and recorded statistically at par to T6, T8 and T9. However, minimum pod damage by pod borer (4.75%) and pod fly (3.45%) were recorded under application of Indoxacarb 15.8 EC @ 375ml ha^{-1} + pulse wonder at flowering and Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later, whereas, maximum loss by pod borer (18.92%) and pod fly (15.30%) recorded under control.

Keywords Pigeon pea, Growth regulators, Insecticides, Foliar spray, Yield.

INTRODUCTION

Pigeonpea (*Cajanus cajan* L. Millsp.) is an erect and short-lived perennial shrub legume crop. India accounts for about 75% of world production. Economically it is the second most important pulse crop after chickpea in India accounting for about 15% of total pulse production (DES, 2021). It is mainly eaten in the form of split pulse as 'dal'. Seeds of arhar are

Dr Satya Narayan Meena*[1], Dr L. K. Meena[3], Dr S.L. Yadav[4]
[1]Assistant Professor (Agronomy), [3]Assistant Professor (Agriculture Economics), [4]Assistant Professor (Agronomy),
Agriculture University, Kota, Rajasthan 324001, India

Dr Pratap Singh[2]
[2]Professor (Agronomy) and Director Research, Agriculture University, Kota, Rajasthan 324001, India

Uditi Dhakad[5], S. N. Regar[6]
[5,6]PhD Research Scholar (Agronomy), Agriculture University, Kota, Rajasthan 324001, India

Dr B. S. Meena[7]
[7]Associate Professor (Agronomy), Agriculture University, Kota, Rajasthan 324001, India

Email: meenasnagro@gmail.com
*Corresponding author

also rich in iron, iodine, essential amino acids like lycine, methionine, cystine and arginine. Pigeonpea cultivated on 4.80 mha area with 4.32 mt of production with an average productivity of 9.0 q ha^{-1}(DES 2021). In Rajasthan, pigeonpea was cultivated on 16.8 thousand ha area with 13.2 thousand ton of production with an average productivity status of 7.85 q ha^{-1}(DES 2021).Vegetative growth of pigeonpea is initially slow and seedlings emerge 2-3 weeks after sowing while, physiological growth picks up in about 2-3 months and plants start flowering during 56-210 days after sowing (DAS) with maturity range from 95 to 256 days (Meena *et al*. 2019).

The productivity of pigeonpea is limited by various biotic and abiotic factors such as agronomic, pathogenic, entomological and genetic. The abiotic constraints may cause higher economic losses to pigeon pea as compared to biotic constraints (Meena *et al*. 2021). Along with nutrients (NPK) hormones are most important factors which have direct effect on metabolism and development of plant and contribute to higher growth and yield (Meena *et al*. 2020). The vegetative and reproductive stage of pigeonpea occurs simultaneously and hence there is competition for available assimilates between vegetative and reproductive sink. On the other hand, always there is a limitation of active source (leaves) particularly at flowering and pod development stages to provide sufficient assimilates (Karuppusamy *et al*. 2021). Apart from its genetic makeup, the major physiological constraints limiting pigeon pea yield are flower and fruit drop (Ojehomon, 1972). In almost all the pulses, flower drop determines the yield and yield attributing parameters. The availability of assimilates, anatomical features of the vascular system and hormonal factors are possible to interact and play a key role in the abscission of reproductive organs. Therefore, a flower and pod abortion result from a temporary shortage of assimilates produced by intense intra-plant competition between vegetative parts, especially the stem apex, and reproductive organs at the beginning of flowering and pod-setting (Karamanos and Gimenez 1991). Retention of flowers and pod conversion produced by the plant gives prospective yield which is possible through foliar application of growth regulators and insecticides which maintain major insect under economic threshold level during flower initiation and pod development stages. The plant growth regulators in general, regulate the physiological parameters such as alteration of plant architecture, assimilation of partitioning, promotion of photosynthesis, enhancement of nitrogen metabolism, promotion of flowering, increased mobilization of assimilates to defined sinks, induction of floral synchrony and delayed leaf senescence (Sharma *et al*. 2013) of field crops which results in increased yield.

The low yields of pigeonpea crop which have remained stagnant for the past 3 to 4 decades are mainly due to insect pest attack and physiological shriveling. In India, nearly three hundred species of insects are known to infest pigeonpea at its various growth stages, of these pod borer (*Helicoverpa armigera*), plume moth (*Exelastis atomosa*) and pod fly (*Melanagromyza obtuse*) are important feeder of pigeonpea, which are collectively referred to as the pod borer complex (Lal and Katti 1998). Pod borers have been estimated to cause 60 to 90% loss in the grain yield of pigeonpea under favorable conditions and the damage of seeds by pod fly generally ranges between 14.3 to 46.6% (Priyadarshini *et al*. 2013). *Helicoverpa armigera* and *Melanagromyza obtusa* cause adequate economic damage leading to very low yield levels of 500 to 800 kg ha^{-1} as against the potential yield of 1800 to 2000 kg ha^{-1} (Durairaj and Shanower 2003, Lal 1996). Keeping the above constraints a necessity was felt to conduct an experiment entitled as "Effect of Plant Growth Regulators in conjunction with Insecticides on the productivity of Pigeon Pea [*Cajanus cajan* (L.) Millsp.]" in the vertisols of Rajasthan, India.

MATERIALS AND METHODS

A field experiment was conducted at Research Farm of Agricultural Research Station, Kota during three consecutive *kharif* seasons (from 2015 to 2018) to find out compatibility between insecticides and growth regulators for enhancing the productivity and profitability of pigeon pea. The study area is situated at 73°.23' E longitude 25°.18' N latitude with an altitude of 271 m above MSL. The soil of the experimental field was clay loam (vertisols) in texture, alkaline in reaction (pH 7.39, 7.42 and 7.38) medium in organic carbon (0.50, 0.48 and 0.52%), medium in available nitrogen (337, 339 and 343 kg ha^{-1}), medium in phosphorus (22.74, 24.02 and 23.75 kg ha^{-1}), high in available potash (398, 386 and 395 kg ha^{-1}) during the year 2015, 2016 and 2017, respectively. The experiment was laid out in Randomized Block design comprising ten treatments viz; indoxacarb 15.8 EC @ 375ml/ha at flowering and chlorantraniliprole (rynaxypyr) 18.5 EC @ 100 g/ha at 15 days later, indoxacarb 15.8 EC @ 375ml/ha at flowering and NAA 40 ppm at 50% flowering, rynaxypyr 18.5 EC @ 100 g/ha at flowering and NAA 40 ppm at 50% flowering, indoxacarb 15.8 EC@ 375ml/ha at flowering and TNAU pulse wonder @ 5.0 kg/ha at 50% flowering, rynaxypyr 18.5 EC @ 100 g/ha at flowering and TNAU pulse wonder @ 5.0 kg/ha at 50% flowering, indoxacarb 15.8 EC @ 375ml/ha + NAA 40 ppm at flowering and rynaxypyr18.5 EC @ 100 g/ha at 15 days later, rynaxypyr 18.5 EC @ 100 g/ha + NAA 40 ppm at flowering and indoxacarb 15.8 EC @ 375ml/ha at 15 days later, indoxacarb 15.8 EC @ 375ml/ha + pulse wonder at flowering and rynaxypyr18.5 EC @ 100 g/ha at 15 days later, rynaxypyr 18.5 EC @ 100 g/ha + pulse wonder at flowering and indoxacarb 15.8 EC@ 375ml/ha at 15 days later and control with three replications. The pigeon pea variety namely ICPL 88039 was tested for this study.The crop was raised under rainfed condition with 60 cm as inter row spacing and 20 cm is followed as intra row spacing using 20 kg ha^{-1} seed rate. A recommended dose of fertilizer (RDF) (20 kg N, 50 kg P_2O_5, 20 kg S and 25 kg $ZnSO_4$ha^{-1}) through urea, SSP and zinc sulphate was applied to all plots as a basal dose. Foliar application of plant growth regulators (pulse wonder and NAA) and insecticides (indoxacarb 15.8 EC and rynaxypyr18.5 EC) were sprayed as per the treatments. Profitability of pigeonpea were analyzed by net return (gross returns - cost of cultivation) and benefits: cost ratio (net returns/cost of cultivation). The observations recorded on pod damage caused by pod borer and pod fly by randomly collecting hundred pods from five randomly selected plants from each treatment at harvest. The data on percent pod damage and grain damage were transformed into angular transformation before statistical analysis to judge significance of difference among different treatments (Fisher 1950).

RESULTS AND DISCUSSION

Growth and yield attributing characters

Data presented in Table 1 revealed that sequential

Table 1. Effect of insecticides and plant growth regulators on growth parameters and yield attributes of pigeonpea.

Treatments		Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Test weight
T_1	Indoxacarb 15.8 EC @ 375 ml ha^{-1} at flowering and Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later	155.8	13.65	170.7	3.8	96.2
T_2	Indoxacarb 15.8 EC @ 375 ml ha^{-1} at flowering and NAA 40 ppm at 50% flowering	165.3	15.78	176.6	3.8	97.5
T_3	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at flowering and NAA 40 ppm at 50% flowering	167.9	16.04	180.0	3.9	98.6
T_4	Indoxacarb 15.8 EC@ 375 ml ha^{-1} at flowering and TNAU pulse wonder @ 5.0 kg ha^{-1} at 50% flowering	161.1	14.84	175.0	3.8	95.6
T_5	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at flowering and TNAU pulse wonder @ 5.0 kg ha^{-1} at 50% flowering	163.6	15.59	176.4	3.8	96.1
T_6	Indoxacarb 15.8 EC @ 375 ml ha^{-1} + NAA 40 ppm at flowering and rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later	186.5	19.05	199.4	4.1	104.3
T_7	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} + NAA 40 ppm at flowering and indoxacarb 15.8 EC @ 375 ml ha^{-1} at 15 days later	192.6	19.6	203.9	4.2	104.8
T_8	Indoxacarb 15.8 EC @ 375ml ha^{-1} + pulse wonder at flowering and rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later	180.9	17.84	192.0	4.0	103.0
T_9	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} + pulse wonder at flowering and Indoxacarb 15.8 EC@ 375 ml ha^{-1} at 15 days later	181.3	18.17	193.8	4.1	103.6
T_{10}	Control	148.5	12.47	154.9	3.4	91.2
SEm±		4.26	0.49	5.07	0.09	1.43
CD (P = 0.05)		12.65	1.47	15.05	0.26	4.26

spray of rynaxipyr 18.5 EC @ 100 g a.i./ha + NAA 40 ppm at flowering followed by indoxacarb 15.8 EC @ 375ml/ha at 15 days late (T7) was recorded significantly higher growth characteristics viz., plant height (192.6 cm) and branches plant^{-1} (19.6) over control by 29.70 and 57.18 %, T1 by 23.62 and 43.59 %,T2 by 16.52 and 24.21%,T3 by 14.71 and 22.19%,T4 by 19.55 and 32.08 %,T5 by 17.73 and 15.19 %, and T8 by 6.47 and 9.87%, respectively, whereas, secured non-significant relationship with T6 and T9.Yield contributing characteristics viz; pods plant^{-1} (203.9), seeds pod^{-1} (4.2) and test weight (104.8 g) was recorded significantly superior under the treatment of rynaxipyr 18.5 EC @ 100 g a.i.ha^{-1} + NAA 40 ppm at flowering and indoxacarb 15.8 EC @ 375 ml ha^{-1} at 15 days later (T7) ascompared to control by 31.63, 23.53 and 14.91%, T1 by 19.45, 10.53 and 8.94%, T2 by 15.46, 10.53 and 7.49, T3 by 13.28, 7.69 and 6.29%, T4 by 16.51, 10.53 and 9.62% and T5 by 15.59, 10.53 and 9.05%. Further, the treatment T7 was recorded non-significant relationship to T6, T8 and T9 in terms of pods plant^{-1}, seeds pod^{-1} and test weight.

The trend of result shows that notably higher vegetative growth parameters viz., plant height and branches palnt^{-1}and superior yield attributing characteristic viz; pods plant^{-1}, seeds pod^{-1} and test weight was recorded under the treatments consisting the application of growth regulators and insecticides in combination as compared to individual. This might be due to foliar application of NAA or pulse wonder which increase in the growth, development and metabolism of pigeon pea and resulted in better vegetative growth, increased dry matter accumulation and reduced the flower drop of pigeon pea through the improvement in translocation of photosynthesis from source to sink. Application of insecticides (indoxacarb 15.8 EC and chlorantraniliprole 18.5 EC) during flowering and pod development stage which maintains the major insects of pigeonpea below ETL and helps the crop to obtained higher growth and yield attributing characteristics. Shinde and Jadhav (1995) also reported that foliar application of NAA at 50 ppm increased the growth and dry matter production in red gram. Similarly, Mahala *et al*. (2001) and Prakash *et al*. (2003) were reported that number of leaves and branches increased by the application of NAA 30 PPM in black gram. The results of present experiment are also in agreement with the findings of Ramanathan *et al*. (2004) and Kadam *et al*. (2008) in which they concluded that application of NAA was found to be more effective for increasing the number of branches, total dry weight, number of pods plant^{-1}, test weight and chlorophyll content in black gram.This might be due to enhanced level of nutrient available in the rhizo ecosystem of the foliar applied nutrients resulting in better plant growth and development.

Yield and economics

Data presented in Table 2 shows that the treatment

Table 2. Effect of insecticides and plant growth regulators on yields, economics and insect incidence of pigeonpea.

Treatments		Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Net return (₹ha^{-1})	B:C ratio	Pod borer (%)	Pod fly (%)
T_1	Indoxacarb 15.8 EC @ 375 ml ha^{-1} at flowering and rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later	1246	2157	46835	2.53	4.87 (12.72)	3.37 (10.53)
T_2	Indoxacarb 15.8 EC @ 375 ml ha^{-1} at flowering and NAA 40 ppm at 50% flowering	1290	2272	50654	2.84	8.16 (16.56)	6.97 (15.26)
T_3	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at flowering and NAA 40 ppm at 50% flowering	1303	2296	51273	2.86	7.76 (16.16)	6.90 (15.19)
T_4	Indoxacarb 15.8 EC@ 375 ml ha^{-1} at flowering and TNAU pulse wonder @ 5.0 kg ha^{-1}at 50% flowering	1269	2238	48434	2.61	8.26 (16.68)	7.13 (15.45)
T_5	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at flowering and TNAU pulse wonder @ 5.0 kg ha^{-1} at 50% flowering	1289	2277	49432	2.65	8.01 (16.40)	6.98 (15.31)
T_6	Indoxacarb 15.8 EC @ 375 ml ha^{-1} + NAA 40 ppm at flowering and rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later	1521	2686	61475	3.10	4.88 (12.69)	3.44 (10.64)
T_7	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} + NAA 40 ppm at flowering and indoxacarb 15.8 EC @ 375 ml ha^{-1} at 15 days later	1550	2748	63059	3.16	4.86 (12.66)	3.86 (11.32)

Table 2. Continued.

	Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Net return (₹ha^{-1})	B:C ratio	Pod borer (%)	Pod fly (%)
T_8	Indoxacarb 15.8 EC @ 375ml ha^{-1} + pulse wonder at flowering and rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} at 15 days later	1477	2600	57920	2.82	4.75 (12.50)	3.45 (10.69)
T_9	Rynaxipyr 18.5 EC @ 100 g a.i. ha^{-1} + pulse wonder at flowering and indoxacarb 15.8 EC@ 375 ml ha^{-1} at 15 days later	1497	2634	59041	2.87	4.95 (12.74)	3.83 (11.23)
T_{10}	Control	1045	1865	39632	2.61	18.92 (25.76)	15.30 (23.01)
SEm±		46.00	102.49	2510.51	0.11	0.75	0.56
CD (P=0.05)		136.66	304.48	7458.25	0.34	2.23	1.67

T7 reported significantly higher seed yield (1550 kg ha^{-1}) and straw yield (2748 kg ha^{-1}) as compared to control by 48.33 and 47.35%, T1 by 24.40 and 27.40%, T2 by 20.16 and 20.95%, T3 by 18.96 and 19.69%, T4 by 22.14 and 22.79%, T5 by 20.25 and 20.69%, respectively. Data shows that the treatment T7 reported significantly higher net return (₹ 63059 ha^{-1}) and B:C ratio (3.16) as compared to control by 59.11 and 21.05 %, T1 by 34.64 and 24.90%, T2 by 24.49 and 11.27%, T3 by 22.99 and 10.49%, T4 by 30.20 and 21.07%, T5 by 27.57 and 19.25%, respectively. Further, the treatment T7 was recorded statistically at par to T6, T8 and T9 in terms of seed yield, straw yield, net return and B: C ratio and they secure the ascending order of T6>T9 >T8. Reason for increased yield under T7 might be due to beneficial effect of sequential application of insecticides and growth regulators at sensitive stage (flower initiation and pod development stages) for yield which reduced flower and pod drop and increase the efficient translocation of photosynthates from source to sink which caused better reproductive growth and final yield of pigeon pea. Kadam *et al*. (2008) reported that NAA application at 30 ppm concentration was significantly increased grain yield, straw yield and economics in black gram. Similarly, NAA was significantly increased the fertility co-efficient in chickpea (Singh 1989). Khalilzadeh *et al*. (2012) application of 100% recommended dose of NPK-DAP 2% +TNAU pulse wonder at 2% on 45 days after sowing can be recommended to exploit the genetic potential and increases the productivity of black gram. This might be due to beneficial effect of nutrients in combination with growth regulators applied at critical stage.

The treatment T7 secured the less infestation of the crop (4.75%) with pod borer as compared to control (18.92%), T1 (4.87%), T2 (8.16%), T3 (7.76%), T4 (8.26%), T5 (8.01%), T6 (4.88%), T7 (4.86%) and T9 (4.95%). Whereas, treatment T7 managed to minimum infestation of the crop (3.37%) with the pod fly attack as compared to control (15.30%), T2 (6.97%), T3 (6.90%), T4 (7.13%), T5 (6.98%), T6 (3.44%), T7 (3.86%), T8 (3.45%) and T9 (3.83%). Treatments viz; T1, T6, T7, T8 and T9 are more effective against pod borer and pod fly as compared to other treatment and keep the population of the insects below ETL. Similar finding was reported by Khamoriya *et al*. (2017) who found that sequential application of Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i./ha as best treatments in managing *M. obtuse* and *H. armigera* proding which decrease pod and grain damage. Patange and Chiranjeevi (2017) found the rynaxypyr 18.5 SP @ 30 g a.i. /ha was most effective insecticide in minimizing the larval population of pigeonpea pod borers viz., gram pod borer, plume moth and pod fly. The treatment showed the lowest pod damage (5.59%) by pod borers and secured highest gain yield of pigeon pea (7.60 q ha^{-1}) and highest B:C ratio.

The sequential spray of rynaxypyr 18.5 EC + NAA 40 ppm at flowering *fb* indoxacarb 15.8 EC at 15 days after of first spray was recorded higher seed yield and economically profitable followed by spray of indoxacarb 15.8 EC + NAA 40 ppm at flowering *fb* rynaxypyr 18.5 EC at 15 days later and indoxacarb 15.8 EC *fb* rynaxypyr 18.5 EC at 15 days later or individual spray of rynaxypyr 18.5 EC or indoxacarb 15.8 EC along with NAA 40 ppm or TNAU pulse wonder 5 kg/ha. The sequential spray of rynaxypyr 18.5 EC + NAA 40 ppm at flowering *fb* indoxacarb 15.8 EC at 15 days after is viable and profitable specially vicinity area of Hadoti region of Rajasthan.

ACKNOWLEDGMENT

The authors are highly thankful to All India Coordinated Research Project on Pigeonpea and Zonal Director Research, ARS, Kota for providing all facilities to conduct the research experiment.

REFERENCES

DES (2021) Agricultural Statistics Division, Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers' welfare, Government of India.

Durairaj C, Shanower TG (2003) Reaction of eight short duration pigeonpea genotypes against pod borer complex in Tamil Nadu, India. *Int Chickpea Pigeonpea Newslett* 10: 47-48.

Fisher RA (1950) Statistical Methods for Research Workers. Oliver and Boyd, Edinburg, London, pp 57–63.

Kadam GR, Kalyankar SV, Borgaonkar SB, Kadam BP (2008) Effect of sowing dates and NAA application on growth, development and yield in blackgram (*Vigna mungo* L.). *Int J Pl Sci* 3(2): 567-569.

Karamanos AJ, Gimenez C (1991) Physiological factors limiting growth and yield of faba beans. Present status and future prospects of faba bean production and improvement in the Mediterranean countries, pp 79-90.

Karuppusamy G, Jeyakumar P, Chandrasekhar CN, Jayamani P, Gopal NO (2021) Foliar application of plant growth regulators and nutrients induce changes in biochemical characters and yield attributes of pigeonpea. *Int J Ecol Environ Sci* 3(1): 158-161.

Khalilzadeh R, Mehdi T, Jalal J (2012) Growth characteristics of Mung bean (*Vigna radiata* L.) affected by foliar application of urea and bio-organic fertilizers. *Int J Agric Crop Sci* 4(10): 637-642.

Khamoriya J, Ram K, Chakravarty S, Mishra VK (2017) Evaluation of sequential application of insecticides against major insect pests on long duration pigeonpea [*Cajanus cajan* (L.) Millsp.]. *J Entomology Zool Stud* 5(3): 1891-1894.

Lal SS (1996) Suppression of pod fly damage in pigeonpea to pulse beetle. *J Appl Biol* 4: 49-51.

Lal SS, Katti G (1998) Integrated pest management of pod borer complex infesting pigeonpea. IPM system in Agriculture, Aditya Book Pvt Ltd New Delhi, India, pp 79–128.

Mahala CPS, Dadheech RC, Kulhari RK (2001) Effect of plant growth regulators on growth and yield of blackgram (*Vigna mungo*) at varying levels of phosphorus. *Crop Res* 18: 163–165.

Meena SN, Jadon C, Meena BS, Meena HP, Singh P, Jat ML (2019) Yield maximization in pigeonpea through various crop management practices in humid south eastern plain zone of Rajasthan. *Int J Bio-resour Stress Manag* 10(6): 593-596.

Meena SN, Jadon C, Meena LK, Meena BS, Yadav, RK, Singh P (2021) Impact of gibberellic acid on growth, yield and economics of pigeonpea (*Cajanus cajan* (L.,). *Ind J Agric Allied Sci* 7 (2): 65-69.

Meena SN, Patidar BK, Jadon C, Meena HP, Meena BS, Yadav RK, Yadav SL, Meena NL, Singh P, Jat ML (2020) Response of pigeonpea (*Cajanus cajan* (L.) to foliar application of nutrient and pest management at flowering stage. *Int J Bio-resour Stress Manag* 11(5): 432-436.

Ojehomon Ojeaga O (1972) Fruit abscission in cowpea, *Vigna unguiculata* (L.) Walp: I. Distribution of 14c-assimilates in the inflorescence and comparative growth of ovaries from persisting and abscising open flowers. *J Experim Bot* 23(3): 751-61.

Patange NR, Chiranjeevi B (2017) Bioefficacy of newer insecticides against pigeonpea (*Cajanus cajan* L. Millsp.) pod borers. *J Entomol Zool Stud* 5(3): 28-31.

Prakash M, Kumar JS, Kannan K, Kumar MS, Ganesan J (2003) Effect of plant growth regulators on growth, physiology and yield of black gram. *Leg Res* 26(3): 183-187.

Priyadarshini GC, Reddy N, Reddy DJ (2013) Bioefficacy of selected insecticides against lepidopteran pod borers in pigeonpea. *Ind J Pl Prot* 41: 6-10.

Ramanathan S, Natrajan K, Stalin P (2004) Effect of foliar nutrition on gain yield of rice fallow blackgram. *Madras Agric J* 91(1-3): 160-163.

Sharma P, Sardana V, Singh K (2013) Dry matter partitioning and source -sink relationship as influenced by foliar sprays in groundnut. *The Bioscan* 8(4): 1171-1176.

Shinde AK, Jadhav BB (1995) Influence of NAA, ethrel and KNO_3 on leaf physiology and yield of cowpea. *Ann Pl Physiol* 9: 43-46.

Singh K (1989) Hormonal regulation of reproductive phenomena and yield in chickpeas. *Ann Pl Physiol* 3: 105-115.