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Evaluation of liquid formulations of *Bt* against gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca vitrata* (Geyer) in pigeonpea

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ABSTRACT

A field experiment was conducted during 2012-13, 2013-14 and 2014-15 at Agricultural Research Station, Darsi, Prakasam district, Andhra Pradesh to evaluate *Bt* liquid formulations and other biopesticides against gram pod borer, *Helicoverpa armigera* and spotted pod borer, *Maruca vitrata* in pigeonpea**.** There were 10 treatments (2 strains of *Bt* liquid formulation each at two doses, powdered *Bt* formulation, two doses of *Beauvera bassiana*, neem formulation, chemical check) including untreated control. Pooled analysis of three years data revealed that two sprays of chlorpyriphos 0.25% at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 0.81 larvae/plant) and *M. vitrata* (av. 0.80 larvae/ inflorescence) on pigeon pea and recorded minimum pod (5.07%) and seed (3.24 %) damage with maximum 16.9 q/ha yield. It was however, at par with the *Bt* strain NBAII-*Bt*G4 @ 2% in respect of pod damage (5.30%), seed damage (3.91%) and yield (15.3 q/ha). The *Bt* strain NBAII-*Bt*G4 @ 2% ranked next best to the insecticidal spray in recording surviving larval population of *H. armigera* (av. 1.01 larvae / plant) and *M. vitrata* (av. 1.10 larvae / inflorescence). Moreover, the treatment PDBC-BT1 @ 2% was also found to be equally effective to superior ones. It is therefore biopesticides should be encouraged as eco-friendly insecticides.

1. INTRODUCTION

Pigeonpea, *Cajanus cajan* (L.) Millsp is an important grain legume crop of the semi-arid tropics. India is the largest producer of pigeonpea contributing to more than 90 per cent of the world's production (3.17 million tonnes) and 817 kg ha^{-1} of productivity [1]. In Andhra Pradesh, it has been grown in an area of about 0.509 million hectares with a production of 0.251 million tonnes and with a productivity of 524 kg ha^{-1}. More than 300 species of insect species have been reported infesting the crop [2] of which those attack pods like spotted pod borer (*Maruca vitrata* (Geyer)) and gram pod borer (*Helicoverpa armigera* (Hubner)) cause considerable yield losses to the pigeon pea growing farmers. Sometimes their infestation level is so high that farmers do not get return even whatever they expended on seed. The pod damage due to *H. armigera* and *M. vitrata* in pigeonpea could vary from 55 to 100% [3, 4, and 5]. In order to reduce the menace by these pests large number of insecticides is being used by ignorant farmers excessively and indiscriminately which leads to development of resistance against insecticides by these pests, adversely affect the crop ecosystem and increase the total cost of production. In recent past more emphasis has been given on safer and eco-friendly management of pests. The relative specificity, potential activity, environmental safety and immunity to insecticides have made microbial pesticides a favored component of Integrated Pest Management (IPM) strategies. Several microbial insecticides like *Bacillus thuriengensis* (*Bt*), *Beauveria* and Nuclear Polyhydrosis Virus (NPV) were already developed as commercial formulations and utilized on *H. armigera* [6, 7, 8 and 9]. Pathogens have been reported to be most important as population regulating factors of *M. vitrata* in the field. The usefulness and effectiveness of *Bt* has been reported on *M. vitrata* [10] in regulating its populations under field conditions. However, work is continuing to develop new *Bt* isolates by different institutes and they may be explored for integrated management of the pod borers.

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Thus attempts were made in present investigation to study the efficacy of *Bt* liquid formulations and other biopesticides in comparison with traditional insecticides against *H. armigera* and *M. vitrata* in pigeonpea.

2. MATERIALS AND METHODS

The field experiment was conducted for three consecutive years (2012-13, 2013-14 and 2014-15) at Agricultural Research Station, Darsi, Prakasam district, Andhra Pradesh. The trial was laid out in randomized block design with ten treatments and three replications. The pigeonpea variety LRG 41 was grown with all suitable package of agronomical practices at 180 x 20 cm spacing in 9 x 5 m plots comprising a total plot size of 1890 sq. mt. The treatments comprised spraying of liquid formulations of *Bt* strains PDBC-*BT*1 @ 1 and 2%, NBAII-*BT*G4 @ 1 and 2%, *Beauveria bassiana* @ 1.5 and 2.0 kg/ha, commercial *Bt* formulation (Halt) @ 0.2%, commercial neem formulation Nivaar 1500 ppm @ 0.2%, chlorpyriphos 20EC @ 0.25% as standard chemical check and untreated control. Two sprays of treatments were given- first spray of treatments was given at pod initiation stage and subsequent spray at fortnightly interval. Observations on the larval population of *H. armigera* and *M. vitrata* were recorded from five randomly selected plants from each treatment a day before treatment application as pre-count and post counts at 3 and 7 days after each spray. Pod damage per cent was estimated by counting the total number of pods and affected ones on five randomly plants in each treatment. At harvest, the pods from individual plots were threshed separately and the yield was recorded from the net plot area. Yield data was converted into quintal per ha. The data recorded on each parameter was subjected to statistical scrutiny by the analysis of variance (ANOVA) technique as described by Panse and Sukhatme (11). The treatment means were compared using the critical difference values calculated at 5 per cent level of significance.

3. RESULTS & DISCUSSION

Pooled analysis of three years data (Tables 1 and 2) revealed that all the treatments significantly reduced larval population of pod borers over untreated check after 3 and 7 days after spraying. Two sprays of chlorpyriphos @ 0.25% at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 0.81 larvae / plant) and *M. vitrata* (av. 0.80 larvae / inflorescence) on pigeon pea. Among the biological options tested for their efficacy in bio suppression of pod borers, NBAII *Bt*G4 @ 2% maintained its supremacy in pod borers management by recording least no. of *H. armigera* (av. 1.01 larvae / plant) and *M. vitrata* (av. 1.10 larvae / inflorescence) and ranked next best to the insecticidal spray. This is followed by PDBC *Bt*1 @ 2% (1.11 *H. armigera* larvae / plant and 1.22 *M. vitrata* larvae / inflorescence) which was at par with NBAII *Bt*G4 @ 1% (1.18 *H. armigera* larvae / plant and 1.30 *M. vitrata* larvae / inflorescence) and PDBC *Bt*1 @ 1% (1.28 *H. armigera* larvae / plant and 1.33 *M. vitrata* larvae / inflorescence) and are comparable with *Beauveria bassiana* @ 2 kg/ha (1.23 *H. armigera* larvae / plant and 1.37 *M. vitrata* larvae / inflorescence) and *Bt* k powdered formulation @ 0.2% (1.28 *H. armigera* larvae / plant and 1.45 *M. vitrata* larvae / inflorescence). Nivaar 1500 ppm @ 0.2% was found to be least effective with a similar larval population count of 1.83 *H. armigera* larvae / plant and *M. vitrata* larvae / inflorescence. By being *Bt* formulation, NBAII *Bt*G4 @ 2% reduced *H. armigera* and *M. vitrata* larval population comparatively early at 7 days after spray, while *Beauvera bassiana* was found more promising at 10 days after spray conforming the quick knock down effect of NBAII *BT*G 4 and sustainable nature of *Beauvera bassiana* in suppressing the target pod borers in pigeon pea ecosystem. However, higher survival of larval population of *H. armigera* (av. 2.55 larvae / plant) and *M. vitrata* (2.30 larvae / inflorescence) was recorded in untreated control. Effectiveness of bio-pesticides like *Bt* and neem formulations in reducing the infestation of *H. armigera* in chickpea had already been reported [12 and 13].

It is evident from pooled data presented in Table 3 that the biopesticides evaluated remained statistically at par to each other in harboring natural enemy population. All the biopesticide treatments were eco-friendly to predatory population of spiders (1.93 – 2.73 / plant) and coccinellids (1.33 – 1.80 / plant) and significantly superior to insecticidal check plots (0.80 and 0.23 / plant, respectively) in harboring their populations both after first and second round of imposition of treatments.

Table 1: Effect of *Bt* liquid formulations against *Helicoverpa armigera* in pigeon pea (Pooled data for 2012-13, 2013-14 and 2014-15).

Treatments	No. of *H. armigera* larvae / plant on pigeonpea after						
	I Spray			II Spray			Cumul. Average
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS	
PDBC *Bt*1 @ 1%	0.73	0.47^{bc}	0.40^{bc}	3.60	2.20^{cd}	2.07^{bc}	1.28^{cd}
PDBC *Bt*1 @ 2%	0.80	0.43^{bc}	0.33^{bc}	3.67	2.07^{cd}	1.60^{cde}	1.11^{d}
NBAII *Bt*G4 @ 1%	0.67	0.40^{bc}	0.33^{bc}	3.53	2.47^{c}	1.53^{cde}	1.18^{cd}
NBAII *Bt*G4 @ 2%	0.73	0.37^{c}	0.27^{bc}	4.00	1.93^{cd}	1.47^{de}	1.01^{de}
Beauveria bassiana (Toxin WP 1.15%) @ 1.5 Kg/ha	0.87	0.60^{abc}	0.33^{bc}	3.73	2.80^{bc}	2.00^{bcd}	1.43^{c}
Beauveria bassiana (Toxin WP 1.15%) @ 2.0 Kg/ha	0.73	0.67^{ab}	0.40^{bc}	3.67	2.20^{cd}	1.67^{cde}	1.23^{cd}
Bt k (Halt 5% WP) @ 0.2%	0.93	0.47^{bc}	0.33^{bc}	3.80	2.53^{c}	1.80^{cde}	1.28^{cd}
Nivaar 1500 ppm @ 0.2%	0.87	0.67^{ab}	0.47^{b}	4.20	3.73^{ab}	2.4^{b}	1.83^{b}
Chlorpyriphos 20EC @ 0.25%	1.07	0.33^{c}	0.17^{c}	4.07	1.40^{d}	1.3^{e}	0.81^{e}
Untreated control	0.80	0.87^{a}	0.93^{a}	3.93	4.07^{a}	4.33^{a}	2.55^{a}
CD (P=0.05)	NS	0.30	0.24	NS	0.95	0.58	0.29
CV%	30.39	32.84	34.07	8.66	21.85	16.41	12.54

DAS- Days After Spraying., *Beauveria bassiana* – Toxin 1.15% WP, make- Varsha Bioscience & Technology., *Bt* k– *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, $5X10^7$ spore/mg, make - Biostadt

Table 2: Effect of *Bt* liquid formulations against *Maruca vitrata* in pigeon pea (Pooled data for 2012-13, 2013-14 and 2014-15).

Treatments	No. of *M. vitrata* larvae / inflorecence on pigeonpea after						
	I Spray			II Spray			Cumul. Average
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS	
PDBC *Bt*1 @ 1%	1.00	0.87^{cd}	0.60^{bc}	3.00	2.13^{bc}	1.73^{c}	1.33^{cde}
PDBC *Bt*1 @ 2%	0.87	0.80^{cd}	0.60^{bc}	2.87	1.93^{bc}	1.53^{c}	1.22^{de}
NBAII *Bt*G4 @ 1%	1.13	0.80^{cd}	0.53^{bc}	3.20	2.27^{bc}	1.60^{c}	1.30^{cde}
NBAII *Bt*G4 @ 2%	1.27	0.60^{d}	0.40^{bc}	3.27	1.87^{bc}	1.53^{c}	1.10^{e}
Beauveria bassiana (Toxin WP 1.15%) @ 1.5 Kg/ha	1.13	0.87^{cd}	0.80^{b}	3.13	2.60^{ab}	1.80^{c}	1.52^{c}
Beauveria bassiana (Toxin WP 1.15%) @ 2.0 Kg/ha	1.27	0.87^{cd}	0.67^{bc}	3.27	2.20^{bc}	1.73^{c}	1.37^{cde}
Bt k (Halt 5% WP) @ 0.2%	1.27	1.00^{bc}	0.73^{bc}	3.27	2.27^{bc}	1.80^{c}	1.45^{cd}
Nivaar 1500 ppm @ 0.2%	1.33	1.27^{ab}	1.33^{a}	3.33	2.40^{abc}	2.33^{b}	1.83^{b}
Chlorpyriphos 20EC @ 0.25%	1.20	0.53^{d}	0.33^{c}	3.20	1.67^{c}	0.67^{d}	0.80^{f}
Untreated control	1.20	1.40^{a}	1.33^{a}	3.20	3.13^{a}	3.33^{a}	2.30^{a}
CD (P=0.05)	NS	0.36	0.41	NS	0.77	0.37	0.29
CV%	26.74	22.85	33.24	9.62	20.06	12.07	12.02

DAS- Days After Spraying.
Beauveria bassiana – Toxin 1.15% WP, make- Varsha Bioscience & Technology.
Bt k – *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, 5X10^{7} spore/mg, make – Biostadt.

Table 3: Safety of liquid formulations of Bt on natural enemy populations in Pigeon pea (Pooled data for 2012-13, 2013-14 and 2014-15).

	No. of Spiders / plant				No. of Coccinellids / plant			
	Pre count	I Spray	II Spray	Cumul. Average	Pre count	I Spray	II Spray	Cumul. Average
PDBC *Bt*1 @ 1%	1.07	2.00^{ab}	2.40^{ab}	2.20^{ab}	0.07	1.20^{a}	1.47^{b}	1.33^{b}
PDBC *Bt*1 @ 2%	1.27	2.53^{a}	2.73^{a}	2.63^{a}	0.13	1.20^{a}	2.40^{a}	1.80^{a}
NBAII *Bt*G4 @ 1%	1.80	2.40^{ab}	2.67^{a}	2.53^{a}	0.20	1.27^{a}	1.87^{ab}	1.57^{ab}
NBAII *Bt*G4 @ 2%	1.33	2.27^{ab}	2.53^{a}	2.40^{a}	0.07	1.40^{a}	2.00^{ab}	1.70^{ab}
Beauveria bassiana (Toxin WP 1.15%) @ 1.5 Kg/ha	1.13	1.93^{ab}	2.60^{a}	2.27^{ab}	0.13	1.20^{a}	1.60^{b}	1.40^{ab}
Beauveria bassiana (Toxin WP 1.15%) @ 2.0 Kg/ha	1.00	2.40^{ab}	2.67^{a}	2.53^{a}	0.13	1.27^{a}	1.47^{b}	1.37^{b}
Bt k (Halt 5% WP) @ 0.2%	1.33	2.00^{ab}	2.67^{a}	2.33^{ab}	0.13	1.33^{a}	2.13^{ab}	1.73^{ab}
Nivaar 1500 ppm @ 0.2%	0.93	1.73^{b}	2.13^{b}	1.93^{b}	0.13	1.33^{a}	1.47^{b}	1.40^{ab}
Chlorpyriphos 20EC @ 0.25%	0.87	0.80^{c}	0.80^{c}	0.80^{c}	0.37	0.27^{b}	0.20^{c}	0.23^{c}
Untreated control	1.73	1.87^{ab}	2.67^{a}	2.27^{ab}	0.20	1.20^{a}	1.67^{b}	1.43^{ab}
CD (P=0.05)	NS	0.69	0.36	0.45	NS	0.57	0.67	0.42
CV%	52.65	20.3	8.87	11.83	83.04	28.36	23.75	17.35

Beauveria bassiana – Toxin 1.15% WP, make- Varsha Bioscience & Technology
Bt k – *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, 5X10^{7} spore/mg, make - Biostadt

Table 4: Effect of different *Bt* liquid formulations on pod, grain damage and yield of pigeonpea (Pooled data for 2012-13, 2013-14 and 2014-15)

Treatments	Pod damage (%)	Seed damage (%)	Yield (Q/ha)
PDBC *Bt*1 @ 1%	7.74^{bc}	5.54^{b}	13.5^{bc}
PDBC *Bt*1 @ 2%	7.50^{bc}	5.34^{bc}	14.1^{abc}
NBAII *Bt*G4 @ 1%	6.29^{cde}	4.77^{bcd}	14.2^{abc}
NBAII *Bt*G4 @ 2%	5.30^{de}	3.91^{cd}	15.3^{ab}
Beauveria bassiana (Toxin WP 1.15%) @ 1.5 Kg/ha	8.07^{bc}	5.77^{b}	12.1^{cd}
Beauveria bassiana (Toxin WP 1.15%) @ 2.0 Kg/ha	6.75^{cde}	4.99^{bc}	12.7^{bc}
Bt k (Halt 5% WP) @ 0.2%	7.09^{cd}	5.40^{bc}	13.7^{bc}
Nivaar 1500 ppm @ 0.2%	9.42^{b}	7.62^{a}	11.5^{cd}
Chlorpyriphos 20EC @ 0.25%	5.07^{e}	3.24^{d}	16.9^{a}
Untreated control	12.94^{a}	8.78^{a}	9.2^{d}
CD (P=0.05)	1.97	1.59	3.09
CV%	15.11	16.77	13.53

Beauveria bassiana – Toxin 1.15% WP, make- Varsha Bioscience & Technology.
Bt k – *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, 5X10^{7} spore/mg, make – Biostadt.

It is suggestive that, biological products are relatively safe bio-pesticides to an array of beneficial organisms. Being safer than conventional insecticides the biopesticides will fit well in the management of pod borers of pigeon pea.

The pooled data analysis of three years (Table 4) indicated that pod and seed damage per cent was significantly reduced by all the treatments over untreated check. Minimum pod and seed damage of 5.07% and 3.24% was observed in insecticidal check treatment chlorpyriphos @ 0.25%. It was however, at par with the *Bt* strain NBAII-*Bt*G4 @ 2% in respect of pod damage (5.30%) and seed damage (3.91%) confirming their supremacy in management of pod borers in pigeon pea ecosystem. Moreover, lower concentration of NBAII-*Bt*G4 @ 1% was also found to be equally effective to superior ones in reducing pod damage (6.29%) and seed damage (4.77%) and remained at par to *Beauveria bassiana* @ 2 kg/ha (6.75% and 4.94% pod and seed damage) and *Bt* k powdered formulation @ 0.2% (7.09% and 5.34% pod and seed damage). The application of two sprays of PDBC *Bt*1 @ 2% (7.50% and 5.40%), PDBC *Bt*1 @ 1% (7.74% and 5.54%) and *Beauveria bassiana* @ 1.5 kg/ha (8.07% and 5.77%), respectively showed non-significant variation to each other in their effectiveness in pod and seed damage reduction. These biological treatments were followed by Nivaar 1500 ppm @ 0.2% (9.42% pod damage) but significantly different from untreated control (12.94%). However, highest seed damage of 8.78% was recorded in untreated control and was at par with Nivaar 1500 ppm @ 0.2% (7.62%).

Consequent upon protection of pigeon pea crop with different biopesticides significant increase in yield over untreated control (Table 4) was noticed. Pooled analysis of pod yield was ranged from 9.2 to 16.9 q/ha across the treatments. Pod yield was significantly highest in chemical control (16.9 q/ha) and was followed by at par with both doses of NBAII-*Bt*G4 (15.3 and 14.2 q/ha) and higher dose of PDBC *Bt*1 @ 2% (14.1 q/ha). These were followed by *Bt* k powdered formulation @ 0.2% (13.7 q/ha), PDBC *Bt*1 @ 2% (13.5 q/ha) and *B. bassiana* @ 2 kg/ha (12.7 q/ha) which were on par with each other. Lowest pod yield was recorded in *B. bassiana* @ 1 kg/ha (12.1 q/ha), Nivaar 1500 ppm @ 0.2% (11.5 q/ha) and were on par with untreated check (9.2 q/ha). Though insecticidal treatment recorded highest yield, it had serious repercussions since it reduced the general predators of the pod borers after application. Utilization of fungal pathogens at lower doses does not ensure satisfactory protection of pigeonpea from pod borers. This was evidenced by higher seed and pod damage and lower grain yield in *Beauveria bassiana* @ 1.5 kg/ha treatment. In support of these observations, Kulkarni [14] reported the superiority of *Bt*., next to toxic chemical, over fungal as well as viral pathogens in pigeonpea ecosystem. Superiority of *Bt* formulations against pod borers was also reported in recording highest larval reduction and lowest pod and grain damage and increasing profitability in pigeon pea [15].

4. CONCLUSION

Three years of experimentation on efficacy of *Bt* liquid formulations showed that NBAII *Bt*G4 @ 2% was effective in reducing pod borer population with higher grain yield in pigeon pea ecosystem. Large scale demonstration of NBAII *Bt*G4 may be conducted in comparison with farmers practice over a large area to confirm the effectiveness of NBAII *Bt*G4. For judicious use of synthetic insecticides it is advocated to alter with biopesticides like *Bt*, *Beauveria* for prolonged action, economical, eco-friendly and sustainability of management system.

5. REFERENCES

1. All India Co-ordinated Research Project on Pigeonpea. Project Coordinator's Report. 2014-15; 18-19.
2. Lal SS, Singh NB. *In* Proceedings of National Symposium on Management of Biotic and Abiotic Stresses in Pulse Crops. Indian Institute for Pulse Research, Kanpur, India. 1998; 65-80.
3. Thakur RC, Neema KK, Singh OP. Losses caused by pod fly (*M. obtusa)* and pod borer (*H. armigera)* to pigeonpea in Madhaya Pradesh. Bhartiya Krishi Anusandhan patrika. 1989; 4: 107-111.
4. Bant SK, Harpreet KC. Evaluation of pigeonpea genotypes for resistance to pod borer complex, Indian Journal of Crop Science. 2006; 1(1-2): 194-196.
5. Malathi S, Vanisree S, Radhakrishna KV, Jalapathi Rao L. Response of Certain Pigeonpea Entries against Legume Pod Borer, Helicoverpa armigera. The Andhra Agricultural Journal. 2008; 55 (1): 235-236.
6. Rabindra RJ, Jayaraj S. Larval extracts and other adjuvants for increased efficacy of nucler polyhedrosis virus against *Heliothis armigera* larvae. Journal of Biological Control. 1988; 2: 102 – 105.
7. Sarode SV, Deotale RO, Jumde YS, Thakare HS. Field evaluation of Heliothis nuclear polyhedrosis virus (HaNPV) for the management of *Helicoverpa armigera* (HB.) on pigeonpea. Indian Journal of Plant Protection. 1994; 56: 176 - 179.
8. Srinivasa M, Jagadeesh Babu CS, Anitha CN, Girish G. Laboratory evaluation of available commercial formulations of HaNPV against *Helicoverpa armigera* (Hub.). Journal of Biopesticides. 2008; 1(2): 138 - 139.
9. Shivanand R, Yankanchi, Sachinkumar R, Patil. Field efficacy of plant extracts on larval populations of *Plutella xylostella* L. and *Helicoverpa armigera* Hub. and their impact on cabbage infestation. Journal of Biopesticides. 2009; 2(1): 32 – 36.
10. Karel AK, Schoonhoven AV. Use of chemical and microbial insecticides against pests of common beans. Journal of Economic Entomology. 1986; 79: 1692-1696.
11. Panse VG, Sukhatme BV. Statistical methods for Agricultural workers, ICAR publication, New Delhi. 1967; pp. 100-161
12. Neerja Agrawal, Ram M. Preliminary field evaluation of biopesticides against gram pod borer, *Helicoverpa armigera* Hubner infesting chickpea. Insect Environment. 2013; 19(1): 8-10
13. Bhushan S, Raj Pal Singh, Ravi Shanker. Bioefficacy of neem and *Bt* against pod borer, *Helicoverpa armigera* in chickpea. Journal of Biopesticides. 2011; 4(1): 87 – 89.
14. Kulkarni NS. Utilization of fungal pathogen *Nomuraea rileyi* (Farlow) samson in the management of lepidopterous pests. Ph.D. thesis, University of Agricultural Sciences, Dharwad. 1999; 154.
15. Gundannavar KP, Lingappa S, Giraddi RS. Biorational approaches for the management of pod borer in pigeonpea ecosystem. Karnataka Journal of Agricultural Sciences. 2004; 17(3): 597-599.

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