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Studies on the Effect of Honeybee Pollination on Seed Yield and Quality of Pigeon Pea (*Cajanus cajan* L.)

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Abstract

The study was carried out during 2010 to 2013 at National Seed Project, UAS, Bengaluru. Observation on insect pollinators and their abundance on pigeon pea revealed that 29 insect species belonging to six orders and 14 families were visited the flowers and helped in pollination of the crop. The maximum abundance (55.75%) belongs to the members of *Apidae* followed by *Megachilidae* (29.33%) and X*ylocopidae* (10.80%). The results also revealed that the honey bee, leaf cutter bees, carpenter bees and blue butter flies were predominant. The highest pod set per plant (531), total number of seeds (1335) and 100 seed weight (14.44 g) was in open pollinated plot, whereas, 483, 1279 and 14.56 g in bee pollinated plot and the least (420, 1099 and 14.16 g) was in self pollinated crop. The highest seed yield (30.50 q / ha) was in open pollinated plot, followed by bee pollinated plot (28.33 q / ha) with per cent increase of 37.63 and 27.84, respectively. The highest seed germination (92.00%) was in open pollinated plot followed by bee pollinated plot (90.00%) with seedling vigour index - I and II of 1747 and 37.29, respectively.

Keywords : Pigeon pea, polinators, honey bee polination

Pigeon pea (*Cajanus cajan* L.) is a protein rich vegetarian diet commonly known as redgram, tur and arhar. Pigeon pea is the crop of semi arid region and has an important place in farming system. It is gown in wide range of agro ecological situations of low and uncertain rainfall regions (Anon, 2005). Karnataka is one among the important states in the country cultivating pigeon pea and contributing 16 per cent of area *i.e.,* 5.96 lakh hectares and 12 per cent of production (2.8 lakh tonnes) with an average productivity of 704 kg / ha (Anon, 2007). Further, the pigeon pea flowers are rich source of pollen and nectar, which attracts many insect pollinators including honeybees. But, no much information is available in pigeon pea on effect of number of bee visits on yield parameters, except some studies on horticulture crops. Pollination is one of the important factors in increasing crop productivity. The hindrance in cross pollinated crops to set fruit or seed can be managed by external agents completing the pollination process. Insect pollinators are responsible for cross pollination by transporting the pollen between different cultivars. The plants mediated by the insects for their flowers to get pollinated are called entomophilous plants. In this regard, honeybees are the cost free bio inputs in farming system. They increase cross pollination, there by playing a sustainable role in increasing level of crop production. Bee pollination not only increases the yield level, but also improves the quality of seeds, creates variation and maintains the gene flow in the ecosystem, there by conserving the crop varietal diversity. Many experiments have confirmed the above fact that efficient use of pollinators can significantly increase the yield level.

Material and Methods

The experiment was carried out at National Seed Project, Gandhi KrishiVignana Kendra, University of Agricultural Sciences, Bengaluru. The pigeon pea was raised following all the recommended package of practices. Five plants were randomly selected to record different species of pollinators visiting the flowers of pigeon pea. The relative abundance of the honeybee species and other pollinators visiting pigeon pea were recorded from 0800 to 1600 h at hourly interval for 5 minutes during peak flowering period at five marked locations of one square meter area of the crop at four days interval. The insect pollinators visiting

the crop were recorded in each spot, worked out the mean and expressed as mean number of pollinators visited per square meter per five minutes.

Further to study the impact of different modes of pollination on productivity of pigeon pea, the crop was grown in 1000 sq.m or more area following recommended cultural practices, by imposing following treatments *viz.,* T1 = Three random plots of 3m x 2m was covered with insect proof net cages (length = 5 cm, width = 2m) at bud stage to avoid cross pollination; T2 = Three random plots of same size to avoid self pollination and T3 = Three random plots of same size with partially caged with insect proof net with 8 frame honey bee colony to facilitate pollination by bees.

For open pollination, all the species of pollinators were allowed to visit the pigeon pea, whereas, in case of pollination with *A.cerena* the plots were covered with nylon mesh (1 mm size) and respective colony was kept inside the net during ten per cent flowering. While forself pollination, the plots were covered with nylon mesh and no pollinators were allowed to visit the pigeonpea. The cages were removed after completion of flowering along with bee hive box, in order to study the role of honeybees in enhancing the productivity. Among quantitative parameters pods per plant, number of seeds per plant, seed weight per plant and 100 seed weight were calculated by randomly selecting five plants after seed maturity. The pods were harvested and dried.Seeds were separated from the pods and counted. The mean number of seeds per plant were expressed and weighed for mean seed weight per plant. The 100 seeds were randomly selected and weighed by using single pan digital electronic balance and expressed in grams.

Observations on germination, seedling vigour index I and II were recorded as prescribed by International Seed Testing Association (ISTA, 2010). The data was analyzed statistically. The germination test was conducted by between paper method by randomly selecting 100 pigeonpea seeds from each treatment and replication. Germination counts were recorded on 8th day after incubation in germination chamber maintained at 25^{0}C with 90 per cent relative humidity. Ten randomly selected seedlings from germination test in each of the treatment and replication were used for measurement of root and shoot length and mean seedling length was calculated.Same seedlings were dried in hot air oven maintained at 80±2^{0}C for 24 hours, then dry weight was computed to find out seedling vigour index I and II by applying formula as suggested by Abdul Baki and Anderson (1973).

Seedling Vigour Index-1 = Germination (%) x Mean seedling length (cm)

SeedlingVigour Index-II = Germination (%) x Mean dry weight of seedling (g)

Results and Discussion

Pooled data of insect pollinators and their abundance in pigeon pea : Observations were recorded on temporal abundance of insect pollinators at peak flowering stage of pigeon pea (Table I). Thirty different species of insect pollinators were recorded of which six species belongs to family *Apidae* accounting 55.75 per cent abundance, followed by species of family *Megachilidae* with 29.33 per cent abundance and four species of family *Xylocopidae* with 10.80 per cent abundance. Totally, 21 species belongs to order *Hymenoptere*, 4 species to Lepidoptera and one each to *Diptera*, *Coleoptera*, *Hemiptera* and *Thysonoptera* accounting to 6.18 per cent abundance.

Abundance of different pollinators visit (number) at flowering stage of pigeon pea : The results revealed that the mean abundance of different pollinators was maximum by honey bee (11.45 / plant / 5 min) during 9-10 AM of the day followed by carpenter bee (10.05 / plant / 5 min) during 3-4 PM of the day (Table II). These findings are in conformity with Kuberappa *et al.*, 2012 on Chamomile.

Seed quantitative parameters of insect pollination : Observations on yield and seed qualitative parameters revealed that (Table III), the maximum number of pods per plant (531) was observed in open pollination which differed significantly with remaining treatments. The next best was in honey bee pollinated plant (483.20) which differed significantly with caged pollinated (420). These results

TABLE I

Pooled data of insect pollinators and their abundance in pigeon pea (2010-13)

Order	Family	Scientific Name	Abundance (%)	Abundance meant (%)
Hymenoptera	Apidae	*Apis florea* Fab.	19.56	
		A cerana Fab.	13.39	
		Trigona iridipennis Fab.	12.10	55.75
		A. dorsata Fab.	8.80	
		*Ceratinabinghami*Cock.	1.00	
		*Amezillaviolaceae*Lep.	0.90	
	Megachilidae	*Megachilelanata*Fab..		
		M.disjuncta Fab.		
		*M. Carbonaria*Smith.	29.33	29.33
		M. anthracina Smith.		
		M. hera Bingham		
	Xylocopidae	*Xylocopalatipes*Drury		
		X. aestuans Lin.		
		X. amethystine Fab	10.80	10.80
		Xylocopa sp.		
	Vespidae	*Polisterus stigma* Fab.		
		Ropalidia marginata Lep	1.5	1.5
		Vespa cincta Fab.		
	Sphecidae	Sceliphron sp.	0.2	0.2
	Scolidae	*Campsomeris collaris* Fab.	0.25	0.25
	Formicidae	*Componotus compressus* Fab.	0.5	0.5
Lepidoptera	Nymphalidae	DanuschrysippusLep.		
		Erogolismerione Cram	0.4	0.4
	Papilionidae	*Papileodemoleus*Lep.		
	Lycanidae	*Lampidesboeticus* Lin.		
Diptera	Tachinidae	*GoniphthalamusspUnidentified*	0.4	0.4
Coleoptera	Chrysomelidae	*MerilialunulataFab*	0.2	0.2
Hemiptera	Coriedae	*Clavigralla gibbosa spinola* spi.n	0.17	0.17
Thysanoptera	Thripidae	MegalurothripsusitatusBagnall	0.5	0.5

TABLE II

Abundance of different pollinators visit (number) at flowering stage of pigeon pea

Insect pollinators	Time to observation	
	9-10 AM	3-4 PM
leaf cutter bee	7.60	9.15
Carpenter bee	5.95	10.05
Honey bee	11.45	8.45
Blue butterfly	3.10	2.50

are in conformity with Moz *et al.*, 2008 on rape seed; Pordel *et al.*, 2007 on canola. Significant differences were observed with respect to filled seeds. More number of filled seeds (1155) was in open pollination which was on par with honey bee pollination (1102) both of them differed significantly over self pollination (968). Least number of unfilled seeds were observed in caged plot (132.60) which differed significantly with other treatments. Total seed weight did not show significant differences among treatments, however the highest weight (199.34 g / plant and 17.94 q / ha) was in open pollination closely followed by honey bee pollination (170.91g / plant and 15.38 q / ha). Hundred seed weight did not show significant differences among treatments. The highest weight (14.56g) was in honey bee pollination and least was in caged plot (14.16g).These findings are in conformity with Moz *et al.*, 2008 on rape seed; Pordel *et al*., 2007 on canola and Rashmi *et al*., 2010 in tur crop.

Seed yield parameters of insect pollination : The highest seed yield (30.50 q / ha) was in open pollinated crop, followed by bee pollinated (28.33 q / ha) with per cent increase of 37.63 and 27.84, respectively, over self pollinated crop (Table IV). These findings are in conformity with Moz *et al.*, 2008.

TABLE IV

Seed yield parameters of insect pollination

Treatments	Mean yield (kg/plot)	yield (q/ha)	Per cent increase
Open pollination	1.83	30.50	37.63
Honeybee pollination	1.70	28.33	27.84
Self pollination	1.33	22.16	-

Seed yield parameters of insect pollination : The highest seed germination (91.80 %) was in open pollinated plant which was on par with bee pollinated plant (90.00 %) both of them differed significantly over self pollinated plant (85.60 %) (Table V). The highest seedling vigour index-I (1747) was recorded in open pollination followed by bee pollination (1625) and significantly least (1451) was in self pollination. The open and bee pollinated plants recorded significantly highest seedling vigour index-II (37.29 and 35.28 per cent, respectively), whereas self pollination recorded least (22.81).

It can be concluded from the study that pigeon pea is a cross pollinated crop, insect pollinators and honey bees are responsible for cross pollination by

TABLE III

Seed quantitative parameters of insect pollination

Treatments	Pod set/ plant	Number of filled seeds	Number of unfilled seeds	Total number of seeds	Filled seeds Weight (g)	Unfilled seeds Weight (g)	Total seeds Weight (g)	100 seeds Weight (g)
Open pollination	531.00 [a]	1155.60 [a]	179.40 [a]	1335.20 [a]	186.86	12.53 [a]	199.34	14.44
Honeybee pollination	483.20 [b]	1102.00 [ab]	177.80 [a]	1279.80 [a]	161.24	9.64 [c]	170.91	14.56
Self pollination	420.00 [c]	968.20 [b]	132.60 [b]	1099.20 [b]	158.10	11.73 [b]	169.80	14.16
S.Em±	6.94	64.30	11.50	60.01	9.65	0.71	10.90	0.23
CD(P=0.05)	20.82	192.90	34.50	180.03	NS	0.51	NS	NS
CV(%)	2.51	10.36	12.20	8.40	9.91	10.88	10.48	2.80

TABLE V

Seed yield parameters of insect pollination

Treatments	Seed germination (%)	Seedling vigour index-I	Seedling vigour index-II
Open pollination	91.80 [a]	1747 [a]	37.29 [a]
Honeybee pollination	90.00 [a]	1625 [b]	35.28 [a]
Self pollination	85.60 [b]	1451 [c]	22.81 [b]
S.Em±	0.816	22.29	1.41
CD (P=0.05)	2.048	3.10	9.92
CV (%)	2.51	68.68	4.35

transporting the pollen between different cultivators and largely depends on honey bees for pollination in increasing the productivity of the crop.

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