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Growth and yield of short duration Pigeon pea (*Cajanus cajan* (L) Millsp.) as effected by date of sowing and weed management practices

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Abstract
A field experiment was conducted during rainy season of 2015 and 2016 at the Research Farm, Institute of Agricultural Sciences, BHU, Varanasi in sandy clay loam soil to find out the influence of date of sowing and weed management practices in pigeonpea. Results revealed that pigeonpea crop sown on 11 June (D_1) took significantly more number of days for flower initiation, to attain 50 % flowering as well as at maturity but found at par with June 25 (D_2). Maximum number of pods per plant and bolder seeds were observed with early sowing of pigeonpea on June 11 (D_1). It significantly caused marked improvement in grain, stalk yield and harvest index over later sowings of pigeonpea, D_2 and D_3. Weed management practices were not found significantly any variation in days for flower initiation. But with respect to days taken to attain 50 % flowering and maturity, significantly more days were found with two hand weedings at 25 and 50 days after sowing which was statistically at par with W_3,W_4 and W_5 and significantly less number of days were associated with W_1 and W_2. Similar trend was observed with 1000-grain weight. W_6 and W_4 recorded maximum grain, stalk yields and harvest index which was at par with each other and significantly superior to rest of the treatments during both the years.

Keywords: Pigeonpea, date of sowing, weed management, yield, flowering, harvest index

Introduction
Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is an important legume crop of the semi-arid tropics of Asia, Africa and Latin America. It is high in protein (21–25%) and several essential amino acids (Saxena *et al.*, 2010) [9]. Pigeonpea is the second most important pulse crop of India after chickpea. India has the largest acreage under pigeonpea (4.05 m ha) with a total production and productivity of 3.27 mt and 799 kg ha^{-1}, respectively. The increase in area cultivated under pigeonpea, production and productivity from 1970-71 to 2012-13 is 43% (2.66 m ha to 3.81 m ha), 60.6% and 13.7%, respectively (AICRPP, 2016). The increasing trend of area cultivated under pigeonpea has been noticed from 1970-71 to 2012-13 in states like Andhra Pradesh by 142.2%, Karnataka by 115.5%, Odisha by 175.2%, Maharashtra by 69% and Gujarat by 165.1% due to hike in using short duration and medium duration pigeonpea varieties. Pigeonpea is the most preferable crop of rainfed areas because of its well developed tap root system as well as lateral root system, its ability to extract moisture from deeper soil layers made short duration pigeonpea variety a preferable option even in moisture stress conditions which might be the probable reason for increase in area cultivated under pigeonpea in these areas. In states like Punjab and Haryana, cultivation of short duration pigeonpea varieties shown increasing trend of an area, production, and productivity. In Haryana, the increase in area cultivated under pigeonpea is 46%, production and productivity are by 233.3% and 128%, respectively from 1970-71 to 2012-13 (AICRPP, 2014). It leads to follow pigeonpea-wheat cropping system under assured irrigation facilities. Time of sowing, a non-monetary input, has a considerable influence on growth and yield of this crop. It ensures the complete harmony between vegetative and reproductive phases on one hand and climatic rhythm on the other hand. Sole pigeonpea gets heavily infested with weeds due to wide row and plant to plant spacing, slow early growth of crop and frequent rains and inadequate sunlight during *kharif* season. In realizing the yield potential of the crop, sound weed management practices becomes imperative as the weeds start competing fiercely for moisture, nutrients and space with the crop right from the sowing of the crop. Weeds pose a major problem to its productivity which may lead to its yield reduction from 68-80% (Talnikar *et al*.

, 2008) [14]. The critical period is during the first eight weeks after sowing. Keeping all these facts in view, the present study entitled "Growth and Yield of short duration pigeonpea (*Cajanus cajan* (L) Millsp.) as effected by date of sowing and weed management practices" is thus investigated.

Materials and Methods

A field experiment was conducted during rainy season of 2015 and 2016 at the Research Farm, Institute of Agricultural Sciences, BHU, Varanasi in sandy clay loam soil. The soil of the experimental field was sandy clay loam texture with pH 7.46. It was moderately fertile being low in organic carbon (0.44%), available nitrogen (186.38 kg N ha^{-1}), and medium in available phosphorus (18.26 kg P_2O_5 ha^{-1}), potassium (205.30 kg K_2O ha^{-1}) and sulphur (19.30 kg S ha^{-1}). The experiment was laid out in split plot design with three replications. Seeds were sown at the rate of 20 kg ha^{-1} with spacing of 60 cm x 20 cm. Experiment was conducted under rainfed conditions but with pre sowing irrigation during both the years. Three different date of sowing are D_1 -June 11, D_2 - June 25, D_3 -July 09 were allotted to main plots and six treatments (weed management practices) were taken in subplots. They are W_1 - Weedy check, W_2 - Pendimethalin @ 1.0 kg a.i. ha^{-1} (pre-emergence) *fb* one hand weeding at 25 DAS, W_3- Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} (post-emergence), W_4 - Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} *fb* one hand weeding at 50 DAS, W_5 - Imazethapyr @ 100 g a.i. ha^{-1} *fb* one hand weeding at 50 DAS, W_6- Two hand weedings at 25 and 50 DAS. There are 18 treatment combinations with total, 54 number of plots. The pigeonpea cv. UPAS-120, short duration variety was used in the experiment. The recommended dose of 20 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} 20 kg K_2O and 30 kg S ha^{-1} in the form of urea, SSP and MOP respectively were applied. The plot size was 4.8 m x 5.0 m accommodating 8 rows per plot. Herbicides were applied by a knapsack sprayer fitted with a flat fan nozzle with a volume rate of 500 liter/ha. The crop was raised with all other recommended package of practices required. Density and biomass of the total weeds and yield were recorded at harvest during both the years. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984).

Results and Discussion

Phenophasic duration

Pigeonpea crop sown on 11 June (D_1) took significantly more number of days for flower initiation, to attain 50 % flowering as well as at maturity (Table 1) but found at par with June 25 (D_2). While, delayed sowing of pigeonpea on July 09 (D_3) has taken significantly less number of days in all the phenophasic stages. The number of days required was observed to be in the succession of D_1 followed by D_2 and D_3 in descending order during both the years of experimentation. As a whole, the earlier sowing required more time to achieve harvest maturity (152.21 days, 154.15 days), which progressively decreased with delay in sowing and this might be due to extended vegetative phase. Pigeonpea, being sensitive to photoperiod, the phenophases are influenced to a perceptible extent due to sowing time. These results are in likeness with that of Ram *et al.* (2011) [7] who opined that May 15 sown crop took more days to 50 % flowering and maturity. Similar observations were also recorded by Islam *et al.* (2008) [5].

Data (Table 1) further revealed that weed management practices were not found significantly any variation in days for flower initiation. But with respect to days taken to attain 50 % flowering and maturity, significantly more days were found with two hand weedings at 25 and 50 days after sowing which was statistically at par with W_3- Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1},W_4 - Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} *fb* one hand weeding at 50 DAS and W_5 - Imazethapyr @ 100 g a.i. ha^{-1} *fb* one hand weeding at 50 DAS and significantly lesser days were associated with W_1 - Weedy check and W_2 - Pendimethalin @ 1.0 kg a.i. ha^{-1} (pre-emergence) *fb* one hand weeding at 25 DAS during both the years of experimentation. The maximum duration taken to maturity were 151.55 and 153.15 days under W_6 during both the years of study. These findings are in similar lines with Reddy *et al*, 2011 [15].

Table 1: Effect of date of sowing and weed management practices on days to flower initiation, days to 50 % flowering and days to maturity

Treatment		Days to flower initiation		Days to 50 % flowering		Days to maturity	
		2015	2016	2015	2016	2015	2016
A. Date of sowing							
D_1	June 11	82.31	84.59	102.18	104.82	152.21	154.15
D_2	June 25	80.26	82.41	100.51	102.79	149.62	150.43
D_3	July 09	75.85	77.92	97.92	98.43	146.18	148.37
SEm ±		1.24	1.29	1.21	1.23	1.65	1.71
CD (P=0.05)		4.82	5.01	4.71	4.78	6.30	6.65
B. Weed management practices							
W_1	Weedy Check	78.37	80.64	95.18	96.85	142.19	144.84
W_2	Pendimethalin *fb* one HW at 25 DAS	79.95	82.57	95.41	97.05	145.47	146.92
W_3	Pendimethalin *fb* Imazethapyr	80.49	83.86	96.23	98.68	148.89	149.14
W_4	Pendi *fb* Imaz *fb* one HW at 50 DAS	81.98	84.25	97.56	99.73	150.16	152.97
W_5	Imazethapyr *fb* one HW at 50 DAS	80.97	83.87	96.57	98.94	149.21	149.93
W_6	Two HW at 25 DAS and 50 DAS	82.41	84.52	98.12	99.91	151.55	153.15
SEm ±		0.94	0.96	0.91	0.91	1.42	1.46
CD (P=0.05)		NS	NS	2.62	2.63	4.08	4.20

Yield attributes

Maximum number of pods per plant was observed with early sowing of pigeonpea on June 11 (D_1). Significantly lower number of pods per plant were associated with the most delayed sowing date (D_3) during both the years of study (Table 2). It might be due to adequate supply of soil moisture and nutrients and better balance between vegetative phase and sufficient time available for pod setting (Malik and Yadav, 2014) [6]. Moreover, it decreased with later sowing probably due to influence of day-length in the present experimentation. Similar results have also been reported by Islam *et al.* (2008) [5], Ram *et al.* (2011) [7] and Egbe *et al.* (2013) [4.]

The data (Table 2) revealed that the varying dates of sowing of pigeonpea did not cause significant effect on 1000-seed weight. Similarly, Hari Ram *et al.* (2011) [7] opined that 1000-seed weight of pigeonpea remained unaffected due to varying planting dates. Higher 1000-seed weight associated with early sowing of pigeonpea D_1 (11 June) compared to the subsequent delayed sowings (D_2 and D_3) might be attributed to the reason that the crop sown early in the season has spent longer time in the field and accumulated large vegetative growth (source) that ultimately enabled a favourable source sink relationship, which might have supplied required amount of photosynthates to the reproductive parts more precisely to the seed, that might have developed fully and thus resulted in bolder seeds.

All the weed management practices gave significantly higher number of pods plant^{-1} over unweeded check, which had lowest number of pods plant^{-1}. Maximum number of pods plant^{-1} was found with two hand weedings at 25 and 50 days after sowing which was statistically at par with Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} at 25 DAS *fb* one hand weeding at 50 DAS and significantly higher than other weed management practices during both the years of experimentation. These results are in accordance with Reddy *et al.*, 2016, [8]

Significantly higher 1000-grain weight was found with two hand weedings at 25 and 50 days after sowing which was statistically at par with W_3- Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1},W_4 - Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} *fb* one hand weeding at 50 DAS and W_5 - Imazethapyr @ 100 g a.i. ha^{-1} *fb* one hand weeding at 50 DAS and significantly higher than W_1 - Weedy check and W_2 - Pendimethalin @ 1.0 kg a.i. ha^{-1} (pre-emergence) *fb* one hand weeding at 25 DAS during both the years of experimentation.

Table 2: Yield attributes, Yields and harvest index of pigeonpea as influenced by date of sowing and weed management practices

Treatment		Pods plant^{-1}		1000-grain weight (g)		Grain yield (q ha^{-1})		Stalk yield (q ha^{-1})		Harvest index (%)	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
A. Date of sowing											
D_1	June 11	154.61	161.81	82.72	83.13	14.32	15.02	49.97	51.59	22.17	22.45
D_2	June 25	141.98	147.13	81.84	82.20	12.03	12.62	45.94	47.11	20.7	21.12
D_3	July 09	109.96	115.03	80.56	80.82	8.57	8.89	37.42	39.02	18.51	18.41
SEm ±		2.55	2.74	0.62	0.66	0.32	0.36	1.01	1.06	0.52	0.59
CD (P=0.05)		10.08	10.79	NS	NS	1.25	1.41	3.95	4.15	2.04	2.31
B. Weed management practices											
W_1	Weedy Check	93.92	99.12	79.42	79.53	8.59	9.13	37.31	38.26	18.54	19.05
W_2	Pendimethalin *fb* one HW at 25 DAS	117.08	122.28	81.41	80.93	10.45	11.01	41.11	43.20	19.99	20.01
W_3	Pendimethalin *fb* Imazethapyr	140.1	145.3	82.33	82.52	11.87	12.31	45.29	46.06	20.56	20.86
W_4	Pendi *fb* Imaz *fb* one HW at 50 DAS	154.84	161.71	83.15	83.43	13.21	13.79	48.61	50.83	21.20	21.14
W_5	Imazethapyr *fb* one HW at 50 DAS	147.16	153.36	82.44	82.72	12.15	12.65	46.11	47.23	20.66	20.94
W_6	Two HW at 25 DAS and 50 DAS	160.01	166.97	83.21	83.70	13.58	14.15	48.20	49.84	21.81	21.96
SEm ±		2.34	2.42	0.56	0.58	0.22	0.24	0.85	0.89	0.32	0.39
CD (P=0.05)		6.75	6.96	1.61	1.67	0.63	0.69	2.44	2.56	0.92	1.12

Grain and Stalk Yield

Sowing of pigeonpea on June 11 (D_1) significantly caused marked improvement in grain and stalk yield over later sowings of pigeonpea, D_2 and D_3 (Table 2). Early sowing provided better vigour to crop and it also encountered less weed competition consequently resulting into higher productivity. Similar findings were reported with Ram *et al*, 2011 [7] and Singh and Srivastava, 2002 [13]

Among weed management practices, two hand weedings at 25 and 50 DAS and Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} at 25 DAS *fb* one hand weeding at 50 DAS recorded maximum grain and stalk yields which was at par with each other and significantly superior to rest of the treatments during both the years. Lower weed infestation and better plant growth in the above treatments might have lead to higher yields. These findings are in similar lines with Reddy *et al*, 2016 [8] Samant, 2015 [10] and Singh *et al*, 2010 [12].

Harvest Index

Sowing of pigeonpea on June 11 (D_1) recorded significantly higher harvest index (22.17, 22.45) during both the years of experimentation (Table 2). Among weed management practices, W_6 (two hand weeding at 25 and 50 DAS) recorded higher harvest index (21.81, 21.96) which was significantly superior over rest of the treatments during both the years but was statistically at par with W_4 (Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} at 25 DAS *fb* one hand weeding at 50 DAS). Weedy check recorded significantly lower harvest index during both the years of study.

Conclusion

Short duration pigeonpea should be sown on June 11 with the application of Pendimethalin @ 1.0 kg a.i. ha^{-1} *fb* Imazethapyr @ 100 g a.i. ha^{-1} at 25 DAS *fb* one hand weeding at 50 DAS for enhanced pigeonpea yield.

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