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Effect of Sowing Time and Supplemental Irrigation on Yield and Economics of *rabi* Pigeonpea (*Cajanus cajan* (L.) Millsp.)

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***Abstract* – A field experiment was conducted to study the impact of sowing time and supplemental irrigation on growth and yield of *rabi* pigeonpea at Regional Agricultural Research Station, Lam, Guntur. The results revealed that the maximum grain yields were recorded when the crop sown from 1st September to 1st October. A significant reduction in yield was observed when the crop sown beyond 15th October. Response to three supplemental irrigation was more when compared to that of less number of irrigations (either two or one) given at critical growth stages of pigeonpea with respect to growth and grain yield. Application of three irrigations at 50 days after sowing, flowering initiation and pod development recorded significantly higher grain yields (1701 kg ha^{-1} and 1595 kg ha^{-1}), net returns (Rs. 55,773/- and Rs. 61,023/-) and BCR (0.97 and 1.12), respectively, during both the years of study.**

***Keywords* – *Rabi* Pigeonpea, Productivity, Supplemental Irrigation, BCR.**

I. INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] commonly known as redgram, *tur* or *arhar* is the fifth prominent legume crop in the world. India, Myammar, Malawi, Kenya, Uganda and Tanzania are the major pigeonpea producing countries. It has been recognized as a valuable source of protein for the vegetarians in their daily diet. In India, pigeonpea is the second most important pulse crop of India which has diversified uses as food, feed, fodder and fuel, next to chickpea producing 3.29 million tons annually from 3.88 million ha [1]. The Indian sub continent alone contributes nearly 92 per cent of the total pigeonpea production in the world. Although India leads the world both in area and production of pigeonpea, its productivity is lower (697 kg ha^{-1}) than the world average (775 kg ha^{-1}) [1]. It is one of the protein rich legume crops of semi-arid and sub-tropics and requires due attention in view of large scale shortage of pulses to meet the domestic requirement. Although pigeonpea ranks sixth in area and production in the world in comparison to other grain legumes such as beans, peas and chickpea, it is used in more diverse ways than others [2]. It is an energy rich crop but cultivated largely under energy starving situations.

However, *rabi* pigeonpea had a potential for maximum seed yield. The productivity of pigeonpea was found to be very low under rainfed condition. However, the demand for Pigeonpea dal is increasing with premium price. Introduction of pigeonpea under *rabi* situation is compelled to initiate an experiment on pigeonpea to study the feasibility of pigeonpea cultivation during *rabi*. Several workers reported that the yields of *rabi* pigeonpea are high as compared to *kharif* pigeonpea. Seed yield of Pigeonpea 31.8 and 66.8 percent less was recorded respectively in 30th October and 14th November sown crop compared to 15th October sowing and attributed this decline is due to higher temperatures at pod development stage that led to high respiration rate and there by reduced amount of photosynthates to be translocated for developing grain [3]. Similar findings were also reported from West Bengal that delayed sowing from September to November resulted in the lowest growth attributes as well as seed yield of pigeonpea [4].

However, the flowering in pigeonpea should not coincide with hot weather as this may lead to severe flower drop resulting in low yields. Hence, this study is envisaged to find out optimum time of sowing and supply of one or two supplemental irrigations at critical stages of crop growth which may result in higher grain yields.

II. MATERIAL AND METHODS

Field experiment was conducted during *rabi* season of 2014 and 2015 at RARS, Lam, Guntur, AP to study the impact of sowing time and supplemental irrigation on growth and yield of *rabi* pigeonpea. The experimental site is located at 16^0 18^1 N latitude, $80^0 29^1$E longitudes and an altitude of 33 m above mean sea level. The soil of the experimental site was clay loam in texture with soil pH was neutral in reaction (7.4) and an electrical conductivity of 0.22dSm^{-1}. The soil organic carbon content (0.51%) and available nitrogen (223 kg ha^{-1}) were low. The available phosphorus (23.4 kg ha^{-1}) and potassium (312 kg ha^{-1}) in soil were medium. The experiment was laid out in split plot design and replicated thrice. The details of the treatments were given in table 1 below.

Table: 1 Details of the treatments

Treatments					
Main plot: Dates of sowing			**Sub-plot: Irrigations**		
	2014	2015		2014	2015
D_1	1st September	-	**I_1**	One irrigation	One irrigation
D_2	15th September	15th September	**I_2**	Two irrigations	Two irrigations
D_3	1st October	1st October	**I_3**	Three irrigations	Three irrigations
D_4	-	15th October			
D_5	-	2nd November			

Prior to sowing the field was prepared with the onset of monsoon rains at proper moisture conditions and cultivating twice followed by planking. The spacing adopted was 120 cm X 20 cm. Herbicides pendimethalin was sprayed as pre-emergence (PE) and imazethapyr at 10-15 DAS using 500 L of spray fluid per hectare, as this was followed by intercultivation at 50 DAS. The crop was grown with standard packages of practices for the region. Prophylactic plant protection measures were taken as against the leaf webber and leaf eating caterpillars and crop was harvested when the 95% of pods matured.

Plant height at harvest was recorded for randomly selected five plants. Grain yield data was recorded on whole plot basis and then converted in to kg ha^{-1}. Data on yield components *viz*., branches per plant, pods plant and test weight (100 grain) was also recorded. All data were subjected to analysis of variance as per standard procedures. Gross returns and net returns were calculated after deducting the cost of cultivation Rs.46094/- and 43365/- per ha using average market price of seed Rs. 6650/- and Rs.7250/-, per quintal of Pigeonpea in the coastal districts of Krishna Agro-climatic zone of Andhra Pradesh during the years 2014 and 2015 respectively.

III. Results and Discussions

Growth:

The plant height and number of branches per plant were influenced by time of sowing during both the years of investigation (Table 2). The early sown crop was resulted in significantly more plant height than that of late sown crop, irrespective of supplemental irrigation. A significant reduction in number of branches $plant^{-1}$ was also observed when the crop was sown beyond 1st October than that recorded with 15th October and 2nd November sown crop. The similar findings were also supported these results in respect of pigeonpea from West Bengal[4]. A significant increase was recorded when the crop was provided with supplemental irrigation at critical stages of crop growth stages (50DAS, flowering initiation and pod development stage). Influence of one (50DAS) or two irrigations (flowering initiation and pod development) on branching was not comparable but, there was a significant difference was observed between two (flowering initiation and pod development) and three irrigations (50 DAS, flowering initiation and pod development), irrespective of time of sowing. Adequate and timely supply of nourishment and enhanced the metabolic processes in the plant might have resulted in better growth. The results are in accordance with that of Kumbhar *et al*. [5].

Yield Attributes and Yield:

From the data, it was revealed that the yield components (pods/plant, seeds/pod and test weight) and yield were significantly influenced by time of sowing and supplemental irrigations (Table 2 and 3). The maximum number of pods $plant^{-1}$ and seeds pod^{-1}were recorded when the crop was sown early on 1st September and a significant reduction was noticed with delay of every fortnight interval during 2014. Similarly, in 2015 the highest number of pods $plant^{-1}$ and seeds pod^{-1} were recorded when the crop sown early on 15th September and 1st October compared to that of delayed sowing dates, irrespective of irrigation. There was a sudden decrease in pods $plant^{-1}$ and seeds pod^{-1} noticed when the crop sown after 15th October. Test weight was (100 grain weight) was not influenced when the crop sown on either 1st or 15th September, but comparable difference was observed when the crop sown after 15th September in 2014, however, during 2015, significant reduction in test weight was observed when the crop sown after 15th October. Influence of one (50DAS) or two irrigations (flowering initiation and pod development) on test weight was statistically not comparable but the difference was significant between two (at flowering initiation and pod development) and three irrigations (at 50 DAS, flowering initiation and pod development), irrespective of time of sowing. Among the number of irrigations, three supplemental irrigations significantly increased the yield components *viz*. number of pods per plant, seeds/pod and test weight of pigeonpea as compared to one irrigation (50 DAS) and two irrigations (Flowering initiation and pod development stage). Improvement in soil moisture storage due to irrigation helped the plant to absorb more nutrients from the soil which resulted in increase in seed weight. Similar favourable effect of irrigation on yield components of pigeonpea was recorded by Basu and Bandyopadhyay [6].

Grain yield also drastically influenced by time of sowing, irrespective of supplemental irrigations(Table 3). Early sown (1st September) crop recorded the maximum grain yield (1708 kg ha^{-1}) and beyond this date reduction in grain yield of 9.9% and 28.7% with respect to 15th September and 1st October sown crops, respectively during 2014. But, in 2015 the highest grain yield (1873 kg/ha) was observed with early sown crop at 15th September, and progressive decrease in grain yield with delay in sowing was observed from 1st October to 2nd November. The differences were statistically significant among all the dates of sowings in both the years of investigation. There was drastic reduction in yield was noticed when the crop sown after 15th October, 2014. When sowings are delayed, this may have flowering early resulted in less vegetative growth and matured early and resulted in low grain yield. With delay in sowing, flowering was induced earlier resulting in less vegetative growth and earliness in maturity resulting in low seed yield. These results are in close conformity with those of Krishna Reddy *et al*. [7] and Nene and Sheila [2]. Similar results also reported by Laxminarayana [8] that September 15th sown Pigeonpea had recorded the highest seed yield compared to later dates of sowing. Irrespective of time of sowing, the maximum grain yield (1701 kg ha^{-1} and 1595 kg ha^{-1}) was recorded when the crop received three supplemental irrigations (at 50 DAS, flowering initiation and pod development) and it was significantly superior over two irrigations (at flowering initiation and pod development) (1489 kg ha^{-1} and1467 kg ha^{-1}) and single irrigation (50DAS) (1275 kg ha^{-1} and 1319 kg ha^{-1}) during both the years respectively. Increasing the soil moisture availability through supplemental irrigations improved the number of pods $plant^{-1}$ and test weight that resulted in maximum grain

yield with the application of three irrigations than that of one or two irrigations. It indicates that irrigations at flowering initiation and pod development stages were necessary for higher seed production of pigeonpea during *rabi* season. Irrigation at 50 DAS devoid of irrigation at later stages reduced the seed yield to a greater extent (16.8 % and 11.22 %) compared to those two irrigations given at later stages. This might be due to fact that the moisture stress affects translocation of photosynthates from leaves to grain thus resulting in smaller grains less number of pods and seeds which might have influenced in decreased grain yield. Moisture stress at critical crop growth stages results in pre mature closure of stomata to reduce water loss, might have caused in decreasing carbon dioxide diffusion in to leaves, there by affecting photosynthesis. Many other researchers [6] [9] [10] [11] from elsewhere were also reported that increase in seed yield of pigeonpea due to irrigation through improvement in yield attributing characters. From this result it can be concluded that the critical crop growth stages for irrigations *i.e*. at 50 DAS (branching), flowering initiation and pod development may be advantageous for realizing higher grain yields.

Economics:

The data on economic analysis are presented in table 3 revealed that the highest gross returns (Rs.113582/- and Rs. 135793/-), net returns (Rs.67488/- and Rs.92428/-) and BCR (1.46 and 2.13) recorded with early sowing of pigeonpea 1st September, 2014 and 15th September, 2015, respectively in both the years of the study. Islam *et al*. (2008) also reported the similar result of higher net returns and BCR for early sown pigeonpea. Sowing of *rabi* pigeonpea after 15th October was not economically viable practice. Three irrigations recorded higher cost of cultivation when compared to one irrigation at 50DAS and two irrigations at flowering initiation and pod development stages as it required more labour unit for irrigation. In spite of this, it recorded the maximum grain yield in both the years and that resulted in higher gross returns (Rs.1,13,117/- and Rs.115638/-), net returns (Rs.55,773/- and Rs. 61023/-) and B:C ratio (0.97and 1.12). Due to its higher grain yield in both the years of investigation which provided the economic viability of *rabi* pigeonpea followed by two irrigations and single irrigation. Such findings also obtained by Saritha *et al*. [11].

IV. Conclusions

It was concluded from the results, that the maximum grain yields, high economic returns and B:C ratio were recorded when the crop sown from 1st September to 1st October for *rabi* pigeonpea which was identified as an optimum time of sowing during post-rainy season with provision of three supplemental irrigations at critical growth stages (at 50 DAS, flowering initiation and pod development).

References

[1] FAOSTAT, 2013. http://faostat.fao.org.

[2] Nene, Y. L. and Sheila, V. K. 1990. Pigeonpea: Geography and Importance. *In: The Pigeonpea*, Nene, Y. L., Hall, S.H. and Sheila, V. K. Eds. Pp1-14. CAB International, Wellingford, U.K.

[3] Govind Reddy, M., Ghosh, B.C. and Sudhakar, N. 1991. Studies on scheduling of irrigation to winter pigeonpea. *Indian Journal of Agronomy* 36(1):109-111.

[4] Panse, A.M. and Jana, P.K. 1990. Effect of dates of sowing and growth patterns of pigeonpea (*Cajanas cajan* (L) Millsp) in winter season. *Madras Agricultural Journal*. 77 (5 & 6): 208-211.

[5] Kumbhar,N.M., Patel, J.S.,Gediya, K.M., Suryawanshi, P.K. and Patel, C.J. 2015. Influence of Irrigation Scheduling (IW: CPE ratios) and sulphur on yield, quality and economics of rabi pigeonpea (*Cajanua cajan* L.). *Legume Research*.38 (5): 643-645.

[6] Basu, T.K. and Bandyopadhyay, S.R. 2009. Productivity of *rabi* pieonpea (*cajanus cajan* L. Milsp.) as influenced by scheduling of irrigation. *Journal of Crop and Weed*. 5(2):90-91.

[7] Krishna Reddy,G., P.Maheshwara Reddy,P., Lavanya Kumari, P. and Giridhara Krishna, T.2015. Response of Pigeonpea varieties to time of sowing during *rabi* season. *Journal of Agriculture and Veterinary Sciences*.8 (2):12-15.

[8] Laxminarayana, P. 2003. Response of *rabi* redgram to dates of sowing and row spacings. *Annals of Agricultural Research*. New series 24(1): 187-189

[9] Islam,S., Nanda,M.K. and Mukhergee, A.K.2008. Effect of date of sowing and spacing on growth and yield of *rabi* pigeonpea (*Cajanus cajan* (L.)Millsp.). *Journal of Crop and Weed*. 4(1): 7-9.

[10] Pramod, G., Pujari, B.T., Basavaraja, M.K. Vijay Mahantesh and Venkate Gowda. 2010. Yield, yield parameters and economics of pigeonpea (*Cajanus cajan* (L.) Millsp) as influenced by genotypes, planting geometry and protective irrigation. *International Journal of Agricultural Sciences*. 6 (2): 422-425.

[11] Saritha K.S., Pujari, B.T., Basavarajappa, R., Naik, M.K., Ramesh Babu and Desai , B.K.2012. Effect of irrigation, nutrient and planting geometry on yield , yield attributes and economics of pigeonpea. *Karnataka Journal of Agricultural Sciences*. 25(1):131-133.

Authors' Profiles

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Table: 2 Growth and Yield of Pigeonpea as Influenced by Time of Sowing and Irrigation

Treatments	Plant ht.(cm)		Branches plant^{-1}		Pods plant^{-1}		Seeds pod^{-1}		Test wt.(g)	
Main: Date of sowing	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
D_1- 1st September	163	-	18.1	-	293	-	4.29	-	9.8	-
D_2- 15th September	149	183	17.1	20.1	235	381	4.20	4.66	9.7	10.2
D_3- 1st October	137	156	15.1	19.7	226	382	4.06	4.60	9.2	10.3
D_4-15th October	-	128	-	17.6	-	290	-	4.56	-	9.7
D_5-2nd November	-	106	-	14.2	-	252	-	4.38	-	9.0
Sem±	2.3	2.9	0.47	0.67	5.73	11.03	0.039	0.052	0.10	0.16
CD(0.05)	9.2	10	1.9	2.3	23	38	0.15	0.18	0.4	0.5
CV(%)	4.6	6.1	8.5	11.2	6.8	10.1	2.8	3.5	3.2	4.8
Sub: Supplemental irrigation										
I_1 -One supplemental irrigation at 50DAS	139	138	15.3	16.3	212	273	4.08	4.41	9.2	9.3
I_2-Two supplemental irrigations at flowering initiation and pod development stage	151	143	16.7	17.7	259	330	4.18	4.50	9.5	9.7
I_3-Three supplemental irrigations at 50 DAS, flowering initiation and pod development stage	161	148	18.5	19.6	284	376	4.29	4.73	10.1	10.5
Sem±	3.5	2.3	0.65	0.31	9.25	8.88	0.047	0.062	0.16	0.13
CD(0.05)	10.7	7	2.0	0.9	29	27	0.15	0.18	0.5	0.4
CV (%)	7.0	5.6	11.5	5.9	11.0	9.4	3.4	4.7	5.0	4.5
Interaction	SIG	SIG	NS	SIG	SIG	SIG	NS	NS	SIG	NS

Table: 3 Gross Returns, Net Returns and B: C Ratio as Influenced by Time of Sowing and Irrigation in Pigeonpea

Treatments	Grain yield (kg ha^{-1})		Gross returns (Rs.)		Cost of cultivation (Rs.)		Net returns (Rs.)		B: C ratio	
Main: Date of sowing	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
D_1- 1st September	1708	-	113582	-	46094	-	67488	-	1.46	-
D_2- 15th September	1539	1873	102344	135793	46094	43365	56250	92428	1.22	2.13
D_3- 1st October	1218	1623	80997	117668	46094	43365	34903	74303	0.76	1.71
D_4-15th October	-	1241	-	89973	-	43365	-	46608	-	1.07
D_5-2nd November	-	1105	-	80113	-	43365	-	36748	-	0.85
Sem±	42.4	33.95								
CD(0.05)	167	117								
CV (%)	8.6	7.0								
Sub:Supplemental irrigation										
I_1 -One supplemental irrigation at 50DAS	1275	1319	84788	95628	49844	47115	34944	48513	0.70	1.03
I_2-Two supplemental irrigations at flowering initiation and pod development stage	1489	1467	99019	106358	53594	50865	45425	55493	0.85	1.09
I_3-Three supplemental irrigations at 50 DAS, flowering initiation and pod development stage	1701	1595	113117	115638	57344	54615	55773	61023	0.97	1.12
Sem±	38.9	39.05								
CD(0.05)	120	117								
CV (%)	7.8	9.3								
Interaction	NS	NS								