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Optimising Sowing Time and Nutrient Needs of *rabi* Pigeonpea [*Cajanus cajan* (L.) Millsp.] in *alfisols* of Andhra Pradesh

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ABSTRACT

A field experiment was conducted on sandy clay loam soils of Tirupati Campus of ANGR Agricultural University, Andhra Pradesh to optimise the sowing time and nutrient needs of *rabi* pigeonpea [*Cajanus cajan* (L.) Millsp.] for its sustained productivity and profitability. Three sowing times: II FN of September, I FN of October and II FN of October; three nutrient levels (N-P_2O_5-K_2O kg ha^{-1}): 10-40-0, 20-50-10 and 30-60-20 and two foliar treatments: NAA (25 ppm) and DAP (2%) at 60 DAS, 60 and 80 DAS were tested on LRG 41 pigeonpea cultivar in split-split plot design, replicated thrice. Earliest sown pigeonpea (II FN September) resulted in significantly higher seed yield (1700 kg ha^{-1}) and net returns (` 32239) due to improvement in yield attributes like pod bearing branches $plant^{-1}$, number of pods $branch^{-1}$, number of seeds pod^{-1} and test weight. Highest nutrient level (30-60-20 NPK ha^{-1}) produced significantly higher seed yield (1589 kg ha^{-1}) and net returns (28448) due to improvement in yield attributes. Foliar application of NAA (25 ppm) and DAP (2%) applied at 60 and 80 DAS recorded significantly highest seed yield (1434 kg ha^{-1}) and net returns (24111) due to its positive effect on pigeonpea yield attributes. Benefit:cost ratio was significantly high (2.71) due to earliest sowing, highest level of nutrient supply (2.46) and foliar application of NAA (25 ppm) and DAP (2%) applied at 60 and 80 DAS (2.26). Early sowings resulted in significantly higher seed yields at higher levels of nutrient supply. Foliar application of DAP (2%) at 60 and 80 DAS recorded significantly higher pigeonpea yield with early sowings. Early sown pigeonpea resulted in significantly higher seed yield at all levels of nutrient supply and foliar applications. *Rabi* redgram gave optimum yield and economic returns sown during II FN of September with 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} along with foliar spray of NAA (25 ppm) and DAP (2 per cent) twice at 60 and 80 DAS.

Key words: Foliar application, Nutrient needs, Pigeonpea, Sowing time, Yield attribute.

INTRODUCTION

Pulses continue to be the major source of protein in Indian diets and play a vital role in sustaining agricultural growth. Increasing pulse production is therefore important for improving food availability, soil health, diet quality and nutritional security. Pigeonpea is an excellent source of proteins and amino acids. It is also rich in vitamin C. High levels of carbohydrates present in it help in maintaining a healthy blood sugar level and boosting energy.

Two major factors limiting the productivity of *rabi* pigeonpea are untimely sowing and limited nutrient application. Efficient use of natural resources and applied agro-inputs depends on optimum sowing time. Among the agro-inputs, nutrient management assumes paramount importance for improving the productivity and profitability of *rabi* pigeonpea. Foliar application of growth regulators (NAA) and nutrient solutions (DAP) can also have positive influence on the productivity of pigeonpea. Information is sought to be obtained in the present investigations on optimum sowing time and nutrient needs for improving and sustaining the productivity of *rabi* pigeonpea.

MATERIALS AND METHODS

Field experiments were conducted for two years (2012-13 and 2013-14) at Tirupati Campus of ANGR Agricultural University, Andhra Pradesh for optimising the sowing time and nutrient needs of *rabi* pigeonpea. Experimental field was sandy clay loam, low in organic carbon and available nitrogen, medium in available phosphorus and available potassium. Experiment was laid out on split-split plot design with three replications and the pigeonpea variety tested was LRG 41. The treatments included three sowing times (main plots): II FN of September (T_1), I FN of October (T_2) and II FN of October (T_3); three nutrient levels of N-P_2O_5-K_2O kg ha^{-1} (sub-plots): 10-40-0 (N_1), 20-50-10 (N_2) and 30-60-20 (N_3) and two foliar treatments (sub-sub plots): NAA (25 ppm) and DAP (2%) applied at 60 DAS (F_1) and NAA (25 ppm) and DAP (2%) applied at 60 and 80 DAS (F_2).

Pigeonpea seeds were sown on well-prepared seed bed with a spacing of 45 x 15 cm. Weeds were managed with pre-emergence application of Imazethapyr followed by two manual weedings at 35 and 70 DAS. Fertilsers were applied to supply the nutrients as per the treatments. Entire quantities of fertilisers were applied by placement at sowing.

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Yield attributing characters (number of pod bearing branches plant^{-1}, number of pods branch^{-1}, number of seeds pod^{-1} and test weight) were recorded at harvest and after cleaning the produce from five randomly selected plants in each net plot area. Seed and stalk yields were expressed in terms of kg ha^{-1}. Net returns were computed by subtracting cost of cultivation from gross returns. Benefit: cost ratio (returns per rupee invested) has been computed for each treatment by dividing the gross returns with corresponding cost of cultivation. Recorded and calculated data from two years study were subjected to stastical scrutiny through pooled analysis. Results of the pooled analysis data for the two years has been presented and briefly discussed.

RESULTS AND DISCUSSION

Yield attributes

Yield attributes varied significantly due to treatments (Table 1). Earliest sown pigeonpea (II FN of September) significantly improved the yield attributes (number of pod bearing branches plant^{-1}, number of pods branch^{-1} and number of seeds pod^{-1}) except the test weight which was on par with that of I FN of October (T_2) sowing. Longer vegetative lag phase for efficient use of growth resources, better balance between vegetative and reproductive phase and adequate time for pod setting appears to have contributed for significant improvement in yield attributes of pigeonpea due to earliest sown crop (Laxminarayana, 2003, Mishra *et al.,* 2006, Rani and Reddy, 2010, Ram *et al.,* 2011). Highest nutrient level of 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} (N_3) greatly contributed for significant improvement in yield attributes presumably due to cumulative improvement in different growth parameters and synergistic effect of primary nutrients leading to increased stature of sink coupled with higher magnitude of biomass accrual and efficient translocation of metabolites to the sink (Patel and Patel, (1995), Kantwa *et al.* (2005) and Meena *et al.* (2013). Foliar spray of NAA (25 ppm) and DAP (2%) twice at 60 and 80 DAS (F_2) improved the yield components relative to foliar spray once at 60 DAS (F_1) with significant disparity between them. Reduction in flower drop, increased phloem area of vascular bundle of stalk and pod and supply due to NAA spray and N and P_2O_5 supply through DAP during flower initiation through foliar spray might have contributed to improvement in yield attributes.

Pigeonpea seeded during II FN of September receiving 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} (T_1N_3) significantly improved the yield attributes. Interaction of sowing times and foliar application significantly varied the number of pod bearing branches plant^{-1}. Two foliar applications to early sown pigeonpea (T_1F_2) significantly improved the pod bearing branches plant^{-1} compared to other combinations. Longer vegetative lag phase due to early sowing and adequate availability of N and P_2O_5 during branching due to two foliar applications contributed to more number of pod bearing branches plant^{-1}.

Seed and stalk yield

Significantly, higher seed and stalk yield were with the crop sown during II FN of September (T_1). Cumulative effect of improvement in growth and yield attributes resulted in significantly higher yield with the earliest sown crop Padhi (1995) and Laxminarayana (2003). Application of 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} (N_3) resulted in significantly higher seed and stalk yield. Improvement in growth parameters leading to improvement in yield attributes increased the yield at higher nutrient levels (Meena *et al.,* 2013 and Umesh *et al.,* 2013). Foliar spray of NAA (25 ppm) and DAP (2 %) twice at 60 and 80 DAS (F_2) resulted in significantly higher seed and stalk yields (Table 2) relative to that due to the same foliar spray once at 60 DAS (F_1). It was probable that application of NAA might have induced large number of new sinks leading to greater activity of carboxylating enzymes and rate of protein synthesis. This resulted in higher photosynthetic rate, translocation and accumulation of metabolites in the sink and eventually greater seed production (Dixit and Elamathi, 2007).

Interaction of sowing times and nutrient levels significantly increased the seed and stalk yield of pigeonpea. It appears that, early sowing with higher nutrient dose (T_1N_3) had improved growth parameters (plant height, leaf area, dry matter production and crop growth rate) and yield attributes (number of pod bearing branches plant^{-1}, number of pods branch^{-1}, number of seeds pod^{-1} and test weight) leading to higher seed and stalk yield. Significantly, higher seed yield was with crop sown during II FN of September receiving two foliar sprays at 60 and 80 DAS (T_1F_2) due to N and P_2O_5 availability from flower primordia initiation to seed maturity as DAP was applied through foliar application. Highest nutrient level along with foliar application twice (N_3F_2) resulted in higher seed yield. Earliest sown crop receiving higher nutrient dose and two foliar applications ($T_1N_3F_2$) resulted in the highest seed yield of *rabi* pigeonpea due to efficient use of natural resources and applied nutrients.

Economics

Gross returns, net returns and benefit: cost ratio varied significantly due to times of sowing, nutrient levels and foliar sprays (Table 2). Significantly higher gross and net returns and benefit: cost ratios were with the crop sown during II FN of September due to high seed and stalk yield. Among the nutrient levels, application of 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} resulted in significantly higher gross returns, net returns and benefit: cost ratio due to improvement in yield attributes and seed yield. Foliar application of NAA (25 ppm) and DAP (2 per cent) twice at 60 and 80 DAS resulted in significantly higher gross and net returns as well as benefit-cost ratio compared with that due to same foliar spray at 60 DAS alone because of higher seed yield.

Pigeonpea sown during II FN of September, receiving 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} (T_1N_3) resulted in significantly higher gross and net returns and benefit: cost ratio. Higher leaf area, crop growth rate, dry matter

Table 1: Effect of sowing time, nutrient levels and foliar application on yield parameters of pigeonpea (pooled data over two years).

Treatment	Number of pod bearing branches plant^{-1}	Number of pods branch^{-1}	Number of seeds pod^{-1}	Test weight (g)
T_1	9.60	12.30	4.17	10.08
T_2	7.99	11.15	3.90	9.82
T_3	7.04	8.56	3.54	9.23
SEm ±	0.156	0.120	0.051	0.089
CD (5%)	0.61	0.47	0.20	0.35
N_1	7.27	9.42	3.52	9.37
N_2	8.26	10.71	3.89	9.75
N_3	9.10	11.88	4.21	10.01
SEm ±	0.039	0.077	0.031	0.047
CD (5%)	0.12	0.24	0.10	0.14
F_1	7.99	10.36	3.79	9.60
F_2	8.43	10.98	3.95	9.82
SEm ±	0.011	0.043	0.020	0.026
CD (5%)	0.03	0.13	0.06	0.08
$T_1N_1F_1$	8.19	10.51	3.86	9.59
$T_1N_1F_2$	8.69	11.44	4.02	9.83
$T_1N_2F_1$	9.34	12.23	4.12	10.06
$T_1N_2F_2$	10.01	12.76	4.25	10.15
$T_1N_3F_1$	10.42	13.04	4.34	10.29
$T_1N_3F_2$	10.98	13.79	4.44	10.56
$T_2N_1F_1$	6.89	9.25	3.60	9.55
$T_2N_1F_2$	7.32	9.81	3.71	9.68
$T_2N_2F_1$	7.86	10.85	3.81	9.75
$T_2N_2F_2$	8.23	11.66	3.96	9.85
$T_2N_3F_1$	8.62	12.32	4.08	9.94
$T_2N_3F_2$	9.01	13.02	4.20	10.16
$T_3N_1F_1$	6.06	7.56	2.82	8.65
$T_3N_1F_2$	6.47	7.94	3.09	8.89
$T_3N_2F_1$	6.88	8.19	3.48	9.21
$T_3N_2F_2$	7.21	8.57	3.71	9.48
$T_3N_3F_1$	7.62	9.28	4.02	9.37
$T_3N_3F_2$	7.98	9.84	4.15	9.75
TxN				
SEm ±	0.067	0.134	0.054	0.081
CD (5%)	0.21	0.41	0.17	NS
TxF				
SEm ±	0.019	0.074	0.034	0.045
CD (5%)	0.06	NS	NS	NS
NxF				
SEm ±	0.019	0.074	0.034	0.045
CD (5%)	NS	NS	NS	NS
TxNxF				
SEm ±	0.033	0.128	0.059	0.078
CD (5%)	NS	NS	NS	NS

Table 2: Effect of sowing time, nutrient levels and foliar application on yield and economics of pigeonpea (pooled data over two years).

Treatment	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Gross returns (`)	Net returns (`)	B:C ratio
T_1	1700	7226	50987	32239	2.71
T_2	1329	4102	40307	21559	2.14
T_3	1067	3253	32268	13520	1.71
SEm ±	36.8	52.3	1962	1962	0.104
CD (5%)	144	204	7661	7661	0.41
N_1	1127	4611	34016	16030	1.89
N_2	1379	4867	41588	22839	2.22
N_3	1589	5102	47959	28448	2.46
SEm ±	10.3	6.7	396	396	0.020
CD (5%)	32	21	1219	1219	0.06
F_1	1297	4806	39206	20767	2.12
F_2	1434	4914	43169	24111	2.26
SEm ±	3.6	5.3	196	196	0.011
CD (5%)	11	16	581	581	0.03
$T_1N_1F_1$	1371	6951	41135	23459	2.33
$T_1N_1F_2$	1505	7054	45137	26842	2.47
$T_1N_2F_1$	1650	7198	49497	31058	2.68
$T_1N_2F_2$	1809	7297	54271	35213	2.85
$T_1N_3F_1$	1863	7372	55882	36681	2.91
$T_1N_3F_2$	2000	7485	60003	40183	3.03
$T_2N_1F_1$	976	3769	29615	11939	1.68
$T_2N_1F_2$	1145	3881	34741	16446	1.90
$T_2N_2F_1$	1245	4035	37925	19486	2.06
$T_2N_2F_2$	1407	4144	42495	23437	2.23
$T_2N_3F_1$	1521	4308	46254	27053	2.41
$T_2N_3F_2$	1680	4476	50813	30993	2.56
$T_3N_1F_1$	794	2963	24273	6597	1.37
$T_3N_1F_2$	974	3052	29195	10900	1.60
$T_3N_2F_1$	1066	3218	32339	13900	1.75
$T_3N_2F_2$	1097	3313	33001	13943	1.73
$T_3N_3F_1$	1187	3445	35937	16736	1.87
$T_3N_3F_2$	1285	3528	38865	19045	1.96
TxN					
SEm ±	17.8	11.6	686	686	0.035
CD (5%)	55	36	2112	2112	0.11
TxF					
SEm ±	6.2	9.2	339	339	0.019
CD (5%)	19	NS	1007	1007	NS
NxF					
SEm ±	6.2	9.2	339	339	0.019
CD (5%)	19	NS	NS	NS	NS
TxNxF					
SEm ±	10.8	15.9	587	587	0.033
CD (5%)	32	NS	NS	NS	NS

production and seed yield with early sown crop at higher nutrient dose resulted in higher seed yield leading to higher economic returns. With regard to the interaction, significantly highest gross and net returns were due to earliest sowing receiving foliar spray of NAA (25 ppm) and DAP (2 per cent) at 60 and 80 DAS (T_1F_2) because of high seed yield with this interaction.

It can be concluded that *rabi* redgram gives optimum yield and economic returns if sown during II FN of September with 30-60-20 kg N, P_2O_5 and K_2O ha^{-1} along with foliar spray of NAA (25 ppm) and DAP (2 per cent) twice at 60 and 80 DAS.

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