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Yield and yield components and economics of pigeonpea cultivation as influenced by organic manures and graded levels of zinc sulphate*

Pigeonpea is one of the important pulse crops of India and 91 per cent of the world's pigeonpea is produced in India. The productivity of pigeonpea in India (799 kg ha^{-1}) is far below the average productivity (848 kg ha^{-1}) of world. In India, it occupies an area of about 4.09 million hectares producing 3.27 million tonnes with an average productivity of 799 kg per hectare (Anon., 2010). Pigeonpea is normally cultivated during *kharif* season. The main constraint of production of pigeonpea during *kharif* is the incidence of a serious pest *viz, Helicoverpa armigera* which causes complete devastation of crop if not properly controlled. The longer duration coupled with heavy incidence of pests during flowering and pod formation stage is detrimental to the productivity of pigeonpea which produces profuse vegetative growth at the cost of reproductive growth and takes longer period to mature causing reduction in per day productivity. The optimum date of sowing recommended for pigeonpea is in the month of June. But many a time the monsoon delays sowing beyond second fortnight of July in this region causing conspicuous reduction in yield. The crop is also subjected to prolonged water logging condition in North India, but suffers due to moisture stress in South India during its early growth stage which causes damage to the crop. In view of the above said problems, scientists thought of an alternative season and as a result pigeonpea was introduced during rabi season in areas having mild winter with 2- 3 supplemental irrigations.

The low yield of pigeonpea is mainly attributed to their cultivation on poor soils with inadequate and imbalanced nutrient application, nil application of organic manures and micronutrients like zinc. Since the soils are low in organic matter content, use of organic manures plays a vital role in improving soil physical condition, provides vital plant nutrients and maintains long term productivity of the soil. Zinc plays an important role in chlorophyll formation, carbohydrate metabolism and synthesis of proteins. Zinc is now being regarded as the third most important limiting nutrient element in crop production after N and P (Gupta, 1995). Further the efficiency of applied zinc is very low and there is a need to increase the efficiency of native and applied zinc through the use of organic manures. The use of inorganic fertilizers along with bulky organic manures was found more advantageous in enhancing crop yields. Hence, the study was initiated.

A field experiment was conducted during 2010-11 under protective irrigation during rabi at Agricultural College Farm, Raichur situated in North Eastern Dry Zone (Zone- 2) of Karnataka and located between 16° 15¹ N latitude and 77° 21¹, E longitude with an altitude of 389 meters above the mean sea level. The soil of experimental plot was medium black with sandy loam texture having 0.62 per cent organic carbon, 223.70 kg ha^{-1} of available nitrogen, 33.41 kg ha^{-1} of available phosphorous, 295.50 kg ha^{-1} of available potassium, 0.51 ppm available zinc and a pH of 8.26. The entire quantity of recommended dose of fertilizer for pigeonpea (25:50:: N: P_2O_5 kg ha^{-1}) was applied as basal dose at the time of sowing. Sixteen treatment combinations comprising of three organic manures (FYM @ 6 t ha^{-1}, vermicompost @ 1 t ha^{-1} and poultry manure @ 1 t ha^{-1}) with control and four levels of zinc sulphate (No $ZnSO_4$, $ZnSO_4$ @ 10 kg ha^{-1}, $ZnSO_4$ @ 15 kg ha^{-1} and $ZnSO_4$ @ 20 kg ha^{-1}) were laid out in factorial randomized block design with three replications. The organic manures were applied to respective plots 15 days before sowing as per the treatments and zinc sulphate was applied at the time of sowing. Five plants were tagged at random in net plot area for recording various yield components like number of pods per plant, number of seeds per pod, seed yield per plant (g), 100-seed weight (g) and seed yield (kg ha^{-1}). Seed yield was computed by threshing pods from net plot, cleaned and the seeds weight was recorded. The net returns (₹ ha^{-1}) were calculated by deducting cost of cultivation (₹ ha^{-1}) from gross returns and B C ratio was worked out as a ratio of gross returns (₹ ha^{-1}) to cost of cultivation (₹ ha^{-1}).

The data on yield components, seed yield, stalk yield, husk yield, net returns and B: C ratio is presented in Table 1 and 2.

The present investigations undertaken to study the impact of different organic sources revealed conspicuous effect on grain yield. The grain yield recorded with the application of poultry manure (1,342 kg ha^{-1}) was significantly superior over the grain yield recorded with the application of farmyard manure (1,160 kg ha^{-1}) and control (1,038 kg ha^{-1}) and was on par with the yield obtained in treatment receiving vermicompost (1,299 kg ha^{-1}) (Table 2). The per cent increase in grain yield of pigeonpea was to the tune of 29, 25 and 12 per cent with the application of poultry manure, vermicompost and FYM, respectively over control. The extent of increase in grain yield was 16 and 12 per cent with the application poultry manure and vermicompost, respectively over FYM. The beneficial effect of poultry manure, vermicompost and FYM was reported by Samad (2001) and Ramamurthy and Shivashankar (1995).

In the present study, the significant increase in grain yield with the application of poultry manure can be traced back to the significant increase in number of pods per plant and grain weight per plant over FYM application and control and were on par with the application of vermicompost. The effect of poultry manure and vermicompost on yield and yield attributing characters was conspicuous over the application of FYM and no organics.

The improvement in the yield attributing character like number pods per plant and 100 seed weight have clearly reflected on seed yield per plant, which is an important component directly governing the grain yield. The present study indicated a conspicuously higher grain weight per plant with the application of poultry manure followed by vermicompost and FYM. To compound the significance, the superior treatment registered

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Table 1. Yield and yield parameters of pigeonpea as influenced by organic manures and levels of zinc sulphate.

	Number of pods per plant	Number of seeds per pod	Seed yield per plant (g)	100 seed weight (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Husk yield (kg ha^{-1})	Harvest Index
Organic manures (O)								
O_0: Control (No organic manure)	140.73	3.46	50.40	10.01	1,038	2,825	848	0.220
O_1: FYM @ 6 t ha^{-1}	149.58	3.53	55.54	10.48	1,160	2,995	897	0.230
O_2: Vermicompost @ 1 t ha^{-1}	158.11	3.64	62.06	11.04	1,299	3,143	981	0.240
O_3: Poultry manure @ 1 t ha^{-1}	160.88	3.67	63.71	11.10	1,342	3,218	1,010	0.241
Mean	152.32	3.57	57.93	10.66	1,210	3,045	934	0.233
S. Em. ±	2.07	0.09	1.24	0.15	25	44	12	0.003
C. D. at 5%	5.98	NS	3.58	0.44	73	128	34	0.008
Zinc sulphate levels (Z)								
Z_0: Control (No zinc sulphate)	141.32	3.44	50.64	9.99	1,048	2,839	856	0.221
Z_1: $ZnSO_4$ @ 10 kg ha^{-1}	148.92	3.54	56.32	10.53	1,171	2,995	923	0.230
Z_2: $ZnSO_4$ @ 15 kg ha^{-1}	158.26	3.63	61.74	11.04	1,296	3,147	964	0.239
Z_3: $ZnSO_4$ @ 20 kg ha^{-1}	160.80	3.67	63.03	11.07	1,324	3,201	992	0.240
Mean	152.32	3.57	57.93	10.66	1,210	3,045	934	0.233
S. Em.±	2.07	0.09	1.24	0.15	25	44	12	0.003
C. D. at 5%	5.98	NS	3.58	0.44	73	128	34	0.008
Organics x Zinc sulphate levels (O x Z)								
S. Em. ±	0.027	0.08	0.04	0.04	50	88	24	0.006
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS

NS- Non significant

statistically higher number of pods per plant, yield per plant and 100 seed weight (Table 1).

Among the yield components, seed yield per plant had closer influence on the seed yield per hectare. Significantly higher seed yield per plant was recorded with poultry manure and vermicompost (63.71 and 62.06 g, respectively) over FYM (55.54 g) and control (50.40 g). Significantly higher seed yield per plant was probably contributed by significantly higher number of pods per plant (160.88 and 158.11, respectively) with poultry manure and vermicompost than FYM (149.58) and control (140.73). Along with this, poultry manure and vermicompost recorded significantly higher 100 seed weight (11.10 and 11.04 g, respectively) and it was 11 and ten per cent higher over control. Significantly higher number of pods per plant and 100 seed weight were recorded with poultry manure and vermicompost than FYM and control which is mainly attributed to higher availability of nutrients since poultry manure and vermicompost being high analysis manures. The yield observation recorded with poultry manure and vermicompost were statistically on par with each other.

Among the different organic manures, FYM recorded higher cost of cultivation (₹ 21,663 ha^{-1}) over vermicompost (₹ 21,063 ha^{-1}), poultry manure (₹ 18,863 ha^{-1}) and control (₹ 18,063 ha^{-1}). FYM and vermicompost recorded higher cost of cultivation due to their higher dose of application and higher cost, respectively compared to poultry manure (Table 3). Cost of cultivation was obviously least with control. Similar results of higher cost of cultivation due to application of FYM and vermicompost are reported by Krishna Jagadisha (2002).

But poultry manure registered higher gross returns (₹ 53,680 ha^{-1}) compared to vermicompost (₹ 51,960 ha^{-1}), FYM (₹ 46,400 ha^{-1}) and control (₹ 41,520 ha^{-1}). The gross returns recorded with poultry manure was highest over all other organic manure treatments (Table 2). The net returns was significantly highest with the application of poultry manure (₹ 34,817 ha^{-1}) as compared to the application of vermicompost (₹ 30,897 ha^{-1}), FYM (₹ 24,737 ha^{-1}) and control (₹ 23,457 ha^{-1}). While the significantly highest benefit cost (B: C) ratio was recorded with poultry manure (2.84) compared to vermicompost (2.47), control (2.29) and FYM (2.14). This is mainly due to lowest cost of cultivation and higher net returns recorded with the application of poultry manure compared to other organic manures. B: C ratio is high with FYM but the nutrients retained in soil were more and hence beneficial over long term crop cycle. Similar results of higher net returns and B: C ratio with the application of poultry manure over FYM was reported by Kulkarni (2000) and Samad (2001).

In the present study, the graded levels of $ZnSO_4$ had a significant influence on the grain and stover yield of pigeonpea. Significantly higher seed yield (1,324 kg ha^{-1}) was obtained with $ZnSO_4$ @ 20 kg ha^{-1} when compared to no zinc sulphate (1,048 kg ha^{-1}) and $ZnSO_4$ @ 10 kg ha^{-1} (1,171 kg ha^{-1}) while it was on par with $ZnSO_4$ @ 15 kg ha^{-1} (1,296 kg ha^{-1}) (Table 1). These results coincide with the work of Puste and Jana (1995) in pigeonpea. The per cent increase was to the tune of 26 and 13 per cent over no zinc sulphate and $ZnSO_4$ @ 10 kg ha^{-1}, respectively. The stover yield and harvest index followed the same trend.

The increase in yield can be attributed to the higher availability of assimilates with $ZnSO_4$ @ 20 kg ha^{-1} than no zinc sulphate and $ZnSO_4$ @ 10 kg ha^{-1}. The requirement of the crop could not be fully met with 10 kg ha^{-1}. Significant differences in the seed yield of pigeonpea with $ZnSO_4$ @ 15 and 20 kg ha^{-1} was because of improved growth and yield components *viz.,* total

Table 2. Economic analysis of pigeonpea cultivation as influenced by organic manures and levels of zinc sulphate.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C
Organic manures (O)				
O_0: Control (No organic manure)	18,063	41,520	23,457	2.29
O_1: FYM @ 6 t ha^{-1}	21,663	46,400	24,737	2.14
O_2: Vermicompost @ 1 t ha^{-1}	21,063	51,960	30,897	2.47
O_3: Poultry manure @ 1 t ha^{-1}	18,863	53,680	34,817	2.84
Mean	19,913	48,390	28,477	2.43
S. Em. ±	—	—	412	0.04
C. D. at 5%	—	—	1,192	0.11
Zinc sulphate levels (Z)				
Z_0: Control (No zinc sulphate)	19,350	41,920	22,570	2.17
Z_1: $ZnSO_4$ @ 10 kg ha^{-1}	19,850	46,840	26,990	2.36
Z_2: $ZnSO_4$ @ 15 kg ha^{-1}	20,100	51,840	31,740	2.58
Z_3: $ZnSO_4$ @ 20 kg ha^{-1}	20,350	52,960	32,610	2.60
Mean	19,913	48,390	28,477	2.43
S. Em. ±	—	—	412	0.04
C. D. at 5%	—	—	1,192	0.11
Organics x Zinc sulphate levels (O x Z)				
S. Em. ±	—	—	824	0.08
C. D. at 5%	—	—	NS	NS

NS- Non significant

dry matter production and its distribution into different parts, number of branches per plant, number of pods per plant, seed yield per plant and 100-seed weight. These results are in accordance with the findings of Sangwan and Raj (2004) and Singh *et al.* (2005) in chickpea crop.

The improvement in yield is achieved through improvement in yield attributing characters like seed weight per plant and 100 seed weight which were significantly higher with the application of $ZnSO_4$ @ 15 and 20 kg ha^{-1} over $ZnSO_4$ @ 10 kg ha^{-1} and no zinc sulphate, respectively. The seed weight per plant was greatly influenced by dry matter accumulation in pods. In the present study, seed weight per plant (63.03 g) and 100 seed weight (11.07 g) were significantly higher with the application of $ZnSO_4$ @ 20 kg ha^{-1} over the application of $ZnSO_4$ @ 10 kg ha^{-1} and no zinc sulphate and was on par with that of $ZnSO_4$ @ 15 kg ha^{-1}. The significantly higher seed weight per plant was due to the fulfillment of the demand of the crop by higher assimilation and translocation of photosynthates from source (leaves) to sink (pods).

The seed weight per plant is governed by yield components like number of pods per plant, number of seeds per pod and also 100-seed weight. Significantly higher number of pods (158.26 and 160.80) was recorded with $ZnSO_4$ @ 15 and 20 kg ha^{-1}, respectively when compared to $ZnSO_4$ @ 10 kg ha^{-1} (148.92) and no zinc sulphate (141.32) (Table 1). These results are in accordance with the results obtained by Puste and Jana (1995).

Among different zinc sulphate levels, $ZnSO_4$ @ 20 kg ha^{-1} recorded higher cost of cultivation (₹ 20,350 ha^{-1}) and higher gross returns (₹ 52,960 ha^{-1}) when compared to $ZnSO_4$ @ 15 kg ha^{-1} (₹ 20,100 ha^{-1} and ₹ 51,840 ha^{-1}, respectively), 10 kg ha^{-1} (₹ 19,850 ha^{-1} and ₹ 46,840 ha^{-1}, respectively) and no zinc sulphate (₹ 19,350 ha^{-1} and ₹ 41,920 ha^{-1}, respectively). The net returns and benefit cost ratio recorded with $ZnSO_4$ @ 20 kg ha^{-1} (₹ 32,610 ha^{-1} and 2.60, respectively) was significantly superior than $ZnSO_4$ @ 10 kg ha^{-1} (₹ 26,990 ha^{-1} and 2.36, respectively) and no zinc sulphate (₹ 22,570 ha^{-1} and 2.17, respectively) while it was on par with that of $ZnSO_4$ @ 15 kg ha^{-1} (₹ 31,740 ha^{-1} and 2.58, respectively) (Table 2).

Thus application of poultry manure @ 1 t ha^{-1} recorded higher yield attributes, seed yield and B C ratio compared to FYM @ 6 t ha^{-1} and vermicompost @ 1 t ha^{-1}. Among the different levels of $ZnSO_4$, $ZnSO_4$ @ 15 kg ha^{-1} was found to be economically superior.

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