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Response of organic pigeonpea to drip irrigation, micronutrients and growth regulators in northern dry zone of Karnataka

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Abstract
A field experiment was conducted to study the "Response of organic pigeonpea to drip irrigation, micronutrients and growth regulators in Northern Dry Zone of Karnataka" under medium deep black soilsat Instructional Farm, agriculture college, Vijayapura during *Kharif* 2018. The experiment was laid out in strip-split plot design and replicated thrice. There were twenty treatment combinations comprise of five irrigation levels as main plots and foliar application of micronutrients and growth regulators as four sub plots. The result show that among different irrigation levels, scheduling of irrigation at 40 mm Ep recorded significantly higher number of pods plant^{-1} (185.6), seed weight plant^{-1} (72.9), grain yield (1942 kg ha^{-1}), stalk yield (6437 kg ha^{-1}), net returns (Rs.61341 ha^{-1}) and BC ratio (2.11) and which were on par with irrigation at 30 mm Ep. Among different growth regulators and micronutrients, foliar application of 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ recorded significantly higher number of pods plant^{-1} (183.0), seed weight plant^{-1} (69.8), grain yield (1851 kg ha^{-1}), stalk yield (6249 kg ha^{-1}), net return (Rs. 58,844 ha^{-1}) and BC ratio (2.07). Among the interactions scheduling of irrigation at 40 mm Ep along with foliar spray of 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ recorded significantly higher number of pods plant^{-1} (196.3), seed weight plant^{-1} (87.6), grain yield (2259 kg ha^{-1}), stalk yield (7203 kg ha^{-1}), net returns (Rs. 81,017 ha^{-1}) and BC ratio (2.50).

Keywords: Growth regulators, irrigation levels, micronutrients, pigeonpea, yield

Introduction
Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one among the protein loaded legumes of semi-arid tropics primarily cultivated under rainfed situations. It is the second most imperative crop of pulse after chickpea. It is C_3 and short-day plant produced across the world's tropical and subtropical regions from 30^0 N to 35^0 S latitudes. In India, the most important area under pigeonpea falls around 14^0 and 28^0 N latitudes. It is most drought charitable among pulse crops. It is profound rooted and having many drought tolerant traits.

Pigeonpea occupies 6.22 mha area and 4.74 mt of world's pulse manufacture (Anon., 2015-16) [1]. In India it is grown over an area of 3.96 mha with an annual production of 2.56 mt. Pigeonpea is extensively cultivated in states such as Maharashtra, Uttar Pradesh, Madhya Pradesh and Karnataka.

Scheduling of irrigation is a dynamic component to produce maximum irrigation efficiency as excess or low irrigation equally have harmful effects on productivity of pigeonpea (Jayapaul *et al.*, 1995) [2]. In general, surface irrigation methods mainly furrow irrigation and controlled flooding i.e., ridges and furrow are the common methods of irrigation in pigeonpea. Among these methods, higher amount of irrigation water is lost because of conveyance, evaporation and percolation besides, low application, distribution and use efficiencies. The use of current micro irrigation techniques, such as drip and sprinkler increase crop growth and yield, due to effective use of nutrients and water. Drip irrigation is a slow and accurate application of water in the form of drops directly to the rhizosphere of the crop and thereby it minimizes the loss of water by percolation and evaporation besides, increasing field application and supply efficiencies, finally resulting in improved water use efficiency.

Common problem in pulses, especially in pigeonpea is flower and pod shedding and it is almost 80%, leading to very poor yield (Kaul *et al.*, 1996) [5]. Foliar spray of plant growth regulators at the pre-flowering and po.d filling stages reduce the flower drop to some extent. The plant growth regulators (PGRs) help to retain flowers on the plant when positive at the time of flowering (Ramesh and Thirumuguran, 2001) [9].

Cow urine is used as a foliar spray @ 10% to supply nitrogen, phosphorus, potassium and other nutrients which are essential for healthy plant growth. Vermiwash is a gathering of excretory products and mucus exudation of earthworms if collected properly, is a clear and translucent, pale yellow colour fluid. Vermiwash treatment gives higher levels of total macronutrients (N, P and K) and micronutrients (Fe, Cu, Mg and Zn). There by improve the growth and development of the crop (Varghese and Prabha, 2014) [14]. Application of micronutrients (zinc, iron and molybdenum) are the metallic compounds which are involved in various physiological functions and thereby increase the leaf area index, crop growth rate and relative growth rate leading to better development and productivity of plant. Further they also enhance flower numbers, improve pod set (Prasad 1998) [8].

Materials and Methods

The field experiment was conducted during Kharif season 2018 at College of Agriculture, Vijayapur, Karnataka on medium depth black soils with pH 8.34 and EC 0.29 dS m^{-1}. The soil was medium in organic carbon (0.65%) and available P2O5 (26.1 kg ha^{-1}) and low in available N (260 kg ha^{-1}) and K (280.33). The research trial area falls under the Northern Dry Zone (Zone 3) of Karnataka.

There were twenty treatments as given in Table1 i.e. scheduling of irrigation at 40 mm Ep, 30 mm Ep, 20 mm Ep, critical stages and control (rainfed). Foliar application of growth regulators and micronutrients *viz.* 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$, Vermiwash @ 10%, Cow urine @ 10% and control (no spray) at flower initiation and pod formation stage. The experiment was laid out in strip-split plot design with three replications in plot size of 7.2 m x 5 m.

The recommended dose of FYM @ 6 tones ha^{-1} was incorporated into the soil before sowing and compost and vermicompost in equal proportion were applied equivalent to recommended dose of phosphorus (50 kg P_2O_5 ha^{-1}), so that the recommended nutrients for pigeonpea (25:50 N:P_2O_5 kg ha^{-1}) were met. The crop was sown on 9th July 2018.

The growth, yield observations and yield were recorded from the net plots the economics of each structure was computed with prevailing market prices. The yield was advance computed for, gross and net returns as well B:C to assess the productivity.

Results and Discussion

Effect of irrigation levels and growth regulators on yield and yield attributes of pigeonpea

In the current analysis, it was discovered that irrigation levels and the foliar application of micronutrients and growth regulators had a significant impact on the growths as well as yield-attributing characteristics of pigeonpea. Grain yield was statistically on par (1,757 kg ha^{-1}) with irrigation scheduling at 30 mm Ep, but it was significantly higher (1,942 kg ha-^{1}) with irrigation scheduling at 40 mm Ep compared to control (1,302 kg ha^{-1}).

The increase in yield observed when irrigation was scheduled at 40 mm Ep (300 mm of water) compared to control was 49%, primarily due to drip irrigation, which maximizes water availability during the crop's growing season. These results are consistent with the pigeonpea research conducted by Mahalaxmi *et al.* (2011) [6].

Among various foliar sprays of micronutrients and growth regulators during flowering and pod filling stage of pigeonpea, foliar spray of 50 ppm NAA + $ZnSO_4$ (0.5%) + soluble boron (0.2%) recorded significantly greater grain yield (1,851 kg ha^{-1}) compared to no spray which recorded significantly lower grain yield (1, 373 kg ha^{-1}). The next best method, which produced results comparable to grain yield (1,695 kg ha-1), was foliar spraying 10% vermiwash. NAA promotes cell division, apical dominance, and increased cell enlargement. It increases the amount of flowers and fruit set, promotes uniform flowering, and stimulates the growth of the shoots. Micronutrient foliar spray enhances the production of protein and carbohydrates as well as their translocation to the site of seed formation. These results concur with those of Tekale (2003) [13] and Sondge *et al*. (1993) [12] in pigeonpea.

In the current study, scheduling irrigation at 40 mm Ep recorded significant impact on the stalk and husk yield (6,437 kg ha^{-1}) of pigeonpea but it was comparable to scheduling of irrigation at 30 mm Ep (Table 1). Similar results were observed by Kantwa *et al*. (2005) [4]. Foliar spraying of 50 ppm NAA + $ZnSO_4$ (0.5%) + soluble boron (0.2%) resulted in significantly higher stalk and husk yield (6,249 kg ha^{-1}) compared to no spray which recorded significantly lower stalk yield (5,208 kg ha^{-1}).

In comparison to the control (159.2 plant-1, 52.0 g plant-1, and 10.55 g, respectively), scheduling irrigation at 40 mm Ep produced higher yield traits, primarily pod number (185.65 plant-1), grain weight (72.99 g plant-1), and 100-grain weight (12.12 g) of pigeonpea. The main reason for the higher yield attribute when irrigation was set at 40 mm Ep was that there was enough moisture in the soil to meet the crop's water needs. These results are consistent with the research conducted on chickpea by Muniyappa *et al*. (2017) [7] and pigeonpea by Rana and Malhotra (1989) [9].

Foliar spray of 50 ppm NAA + $ZnSO_4$ (0.5%) + soluble boron (0.2%) recorded significantly higher yield traits mainly pod number (183 $plant^{-1}$), grain weight (69.8 g $plant^{-1}$) and 100-grain weight (11.84 g) of pigeonpea compared to control (166.7 $plant^{-1}$, 64.0 g $plant^{-1}$ and 57.7 g, respectively). It was principally because of decreased flower bud drop and improved number of pod set $plant^{-1}$ with foliar spray of micronutrients and growth regulators Boron treatment might have played a essential role in reducing the flower and pod drop perhaps by avoiding abscission layer progress and is also involved in translocation of sugars from source which finally lead to increased yield of pigeonpea (Ratna *et al*., 1993) [10].

Interactions between nutrient levels and foliar spray of micronutrients and growth regulators

Growth regulators and irrigation levels work together to maintain higher productivity pigeonpea yields. When compared to the previous treatment combinations, the grain yield (2,259 kg ha-1) was significantly higher when irrigation was scheduled at 40 mm Ep along with foliar spray of 50 mm NAA + $ZnSO_4$ (0.5%) + soluble boron (0.2%), with the exception of the scheduling of irrigation at 40 mm Ep along with foliar spray of vermiwash 10% (2023 kg ha-1), which were comparable (Table 1). Rameshwar observed similar outcomes in pigeonpea (2003) [9].

When irrigation was scheduled at 40 mm Ep and foliar sprayed with 50 ppm NAA + $ZnSO_4$ (0.5%) + soluble boron (0.2%), the grain yield was significantly higher than in the control. On par, however, were the results of scheduling irrigation at 40 mm Ep combined with foliar spraying 10% vermiwash (2023 kg ha^{-1}) (Table 1).

Significantly higher husk and stalk yield (7,203 kg ha^{-1}) was recorded with scheduling of irrigation at 40 mm Ep along with foliar spray of 50 ppm NAA + $ZnSO_4$ (0.5%) + soluble boron (0.2%) when compared to control (4,334 kg ha^{-1}) and it was on par with scheduling of irrigation at 40 mm Ep along with foliar spray of vermiwash 10% (Table 1).

Interactions between nutrient levels and foliar spray of micronutrients and growth regulators

Among the treatment combinations, scheduling irrigation at 40 mm Ep in conjunction with foliar spraying 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ yielded significantly higher net returns (81,017 Rs. ha^{-1}) than the control (12,890 Rs. ha^{-1}). It was also statistically comparable to scheduling irrigation at 30 mm Ep in conjunction with foliar spraying 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ (62,772 Rs. ha-1).Among the treatment combinations significantly superior B:C was obtained with scheduling of irrigation at 40 mm Ep along with the foliar spray of 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ (2.50) than control (1.26) and it was statistically at par with scheduling of irrigation at 30 mm Ep in combination with foliar spray of 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ (2.20) (Rameshwar, 2003) [9].

Table 1: Yield and yield parameter of pigeonpea as influenced by irrigation levels, micronutrients and growth regulators

Treatments	Number of pods $plant^{-1}$	Pod weight $plant^{-1}$ (g)	Grain weight $plant^{-1}$ (g)	Number of seeds pod^{-1}	100 grain weight (g)	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
Drip irrigation levels (M)							
M1 = Ep 40 mm	185.6	79.6	72.9	3.65	12.12	1942	6437
M2 = Ep 30mm	181.0	74.6	67.7	3.45	11.63	1757	6033
M3 = Ep 20 mm	175.7	71.5	65.5	3.30	11.36	1636	5737
M4 = Critical stages	169.7	66.0	59.3	3.06	10.92	1465	5465
M5 = Control (rainfed)	159.2	58.9	52.0	2.76	10.55	1302	5001
S.Em ±	2.7	1.6	1.6	0.074	0.22	79	191
C.D. (P=0.05)	9.8	5.8	5.8	0.27	0.81	208	404
Growth regulators and micronutrients (N)							
N1= 50 ppm NAA + 0.2% boron + 0.5% ZnSO4	183.0	76.6	69.8	3.55	11.84	1851	6249
N2 = Vermiwash @ 10%	176.0	71.8	65.2	3.35	11.37	1695	5865
N3 = Cow urine @ 10%	171.2	68.0	61.2	3.12	11.17	1562	5615
N4 = Control (No spray)	166.7	64.0	57.7	2.96	10.87	1373	5208
S.Em ±	3.0	1.7	1.7	0.083	0.246	55	137
C.D. (P=0.05)	8.7	5.8	5.8	0.24	0.71	149	332
Interaction (M×N)							
M1N1	196.3	87.6	80.8	3.93	12.60	2259	7203
M1N2	190.2	80.3	73.4	3.80	12.47	2023	6612
M1N3	179.0	78.5	71.9	3.60	12.17	1904	6333
M1N4	177.0	71.8	65.6	3.27	11.23	1583	5600
M2N1	188.4	79.0	70.9	3.73	12.37	1990	6579
M2N2	180.3	76.1	69.3	3.53	11.67	1857	6253
M2N3	178.7	72.1	65.3	3.33	11.30	1630	5757
M2N4	176.6	71.2	65.3	3.20	11.17	1552	5542
M3N1	181.4	77.8	72.9	3.67	12.07	1869	6257
M3N2	179.6	76.0	70.4	3.47	11.47	1666	5806
M3N3	172.2	68.0	61.1	3.13	11.10	1547	5476
M3N4	169.6	64.4	57.6	2.93	10.80	1464	5407
M4N1	178.9	73.9	67.0	3.33	11.27	1654	5779
M4N2	171.7	65.2	58.3	3.13	10.93	1508	5531
M4N3	168.7	62.4	55.6	2.90	10.77	1461	5393
M4N4	159.4	62.3	56.5	2.87	10.70	1235	5156
M5N1	170.2	64.5	57.7	3.07	10.90	1485	5426
M5N2	158.2	61.3	54.4	2.80	10.31	1423	5125
M5N3	157.4	59.1	52.2	2.63	10.53	1266	5118
M5N4	150.8	50.5	43.7	2.53	10.47	1033	4334
S.Em ±	1.98	1.7	1.8	0.167	0.494	103	230
C.D. (P = 0.05)	5.5	5.7	5.4	0.48	NS	298	664

Table 2: Economics of pigeonpea as influenced by irrigation levels, micronutrients and growth regulators in pigeonpea

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
Drip irrigation levels (M)				
M_1 = Ep 40 mm	55187	116528	61341	2.11
M_2 = Ep 30mm	55387	105673	50286	1.91
M_3 = Ep 20 mm	55812	98551	42739	1.77
M_4 = Critical stages	54195	88608	34412	1.63
M_5 = Control (rainfed)	52369	78935	26566	1.51
S.Em ±	-	4565	4565	0.08
C.D. (P=0.05)		16595	16595	0.3
Growth regulators and micronutrients (N)				
N_1= 50 ppm NAA+0.2% boron +0.5% $ZnSO_4$	53614	111206	57593	2.07
N_2 = Vermiwash @ 10%	57750	102012	44262	1.76
N_3 = Cow urine @ 10%	54549	94232	39683	1.72
N_4 = Control (no spray)	52449	83186	30737	1.58
S.Em ±	-	3134	3134	0.06
C.D. (P=0.05)		9052	9052	0.16
Interaction (M×N)				
M1N1	54161.	135178	81017	2.50
M1N2	58496	121268	62772	2.07
M1N3	55096	114266	59170	2.07
M1N4	52996	95401	42405	1.80
M2N1	54361	119362	65001	2.20
M2N2	58696	111505	52809	1.90
M2N3	55296	98242	42946	1.78
M2N4	53196	93585	40389	1.76
M3N1	54661	112176	57515	2.05
M3N2	59496	100301	40805	1.69
M3N3	55596	93238	37642	1.68
M3N4	53496	88489	34993	1.65
M4N1	53543	99602	46059	1.86
M4N2	56384	91104	34720	1.62
M4N3	54478	88339	33861	1.62
M4N4	52378	75388	23010	1.44
M5N1	51343	89714	38371	1.75
M5N2	55678	85883	30205	1.54
M5N3	52278	77076	24798	1.47
M5N4	50178	63068	12890	1.26
S.Em ±	-	6268	6268	0.11
C.D. (P = 0.05)	-	18105	18105	0.33

Conclusion

It can be concluded that the above result that, scheduling of irrigation at 40 mm Ep along with foliar application of 50 ppm NAA + 0.2% boron + 0.5% $ZnSO_4$ recorded superior yield, yield parameters, net returns and benefit cost ratio.

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