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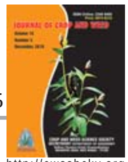

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Effect of land configuration, growth regulators and integrated nutrient management on yield and economics of pigeonpea

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ABSTRACT

The field experiment was conducted during kharif and rabi season of 2015-16 and 2016-17 on clayey soil at the farm of AICRP on Integrated Farming Systems, VNMKV, Parbhani to find out the suitable land configuration, growth regulators and integrated nutrient management .Treatment consists of twenty four treatment combinations comprising three land configurations and two foliar applications in main plot whereas, four integrated nutrient levels in sub plot. Main plot Land Configuration L_1:Flat bed L_2:Ridges and furrow L_3: Broad Bed Furrow Foliar Application F_1: Foliar application of Mepiquat chloride @ 100 ppm at 50% flowering F_2:Foliar application of Cycocel @ 50 ppm at 50% flowering Sub plot Integrated Nutrient Management N_1:100% RDF + Rhizobium + PSB N_2:75% RDF + 2.5 t FYM ha^{-1} + Rhizobium + PSB N_3:50% RDF + 5 t FYM ha^{-1} + Rhizobium + PSB N4: RDN through 1/3 FYM + 1/3 Vermicompost + 1/3 Neem cake + Rhizobium + PSB. The treatments were assigned in split plot design. foliar application of Mepiquat chloride @ 100 ppm at 50% flowering stage and application of 50% RDF + 5 t FYM ha^{-1} + Rhizobium + PSB grown on broad bed furrow obtaining higher seed and straw yields of better quality and maximum economic returns by sustaining soil fertility of pigeonpea.

Keywords: Growth regulators, integrated nutrient management, land configuration and pigeonpea

The pigeonpea has a range of diverse uses. The seed can be eaten fresh as a vegetable or dry in "dhal" a South Asian staple. The seed, pods and leaves are used to feed livestock and the plant functions as well as providing green manure. The dry stems of pigeonpea are also used as fuel. It has soil regulation qualities such as release of soil bound phosphorus, fixation of atmospheric nitrogen, recycling of soil nutrient and addition of organic matter makes pigeonpea an ideal crop of sustainable agriculture in the tropic and subtropics. Pigeonpea is one of the important of Maharashtra state. Pigeonpea is long duration crop and suits under different cropping system either in intercropping or sequence cropping systems. Mostly it is grown as sole crop as well as intercrop with sorghum or soybean in most parts of Maharashtra state. During the year 2016-17, area under pigeonpea in India was 3.86 million hectares with production 2.90 million t (Anon., 2016). In Maharashtra, pigeonpea production during *kharif* 2016-17 was 14.35 lakh hectares and production 20.89 lakh t with the productivity of 1455 kg ha^{-1}. In Marathwada, during the year 2016-17 was 6.04 lakh hectares and production 9.59 lakh tone with the productivity 1459 kg ha^{-1} (Anon., 2018).

In recent years, uncertainties in rain water availability, the swings in the onset, continuity and withdrawal pattern of monsoon has made crop production more risky in *rainfed* areas (Singh, 2000). Under these circumstances efficient rain water management practices acts as insurance for crops during abnormal rainfall situation. For getting a sustainable crop production system under *rainfed* condition, the conservation of rain water and its efficient recycling are imperative. The rain water can be conserved either *in-situ* or *ex-situ* in natural or manmade structures for supplemental irrigation. *In-situ* rain water conservation can be carried out either through tillage or land surface management. Among the various land surface management practices ridges and furrow, broad bed furrow, tied ridges and furrow are very promising in controlling surface runoff, reducing the soil loss through erosion and increasing infiltration. The landform management system essentially reduces the velocity of runoff water and consequently increases opportunity time for water to infiltrate and reduces sediment losses. Further, during the period of heavy rainfall the furrows allow excess water to drain safely from the plots and thus avoid water logging to the crop.

Nowadays, plant growth regulators have been found to play an important role in plant growth and development. Plant growth regulator have enormous application in agriculture such as enhancing seed yield, plant vigour and other yield attributing characters. Plant growth regulators (PGRs) are chemicals, which enhance plant growth, especially when applied in trace quantity. The effectiveness of the PGRs depends on the

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concentration of the chemicals present and the sensitivity of the crop concerned. The plant growth regulators have the capacity to stimulate and inhibit physiological process, which directly or indirectly might affect the crop regulators show a fundamental part in development process and yield of crops. These are synthesized within the plant bodies but its exogenous application renders a considerable response (Frankenberger and Arshad, 1991; Khalid *et al*., 2006).

India has made spectacular breakthrough in production and consumption of fertilizers during last four decades. Because of escalating energy cost, chemical fertilizers are not available at affordable prices to the farmers. Moreover, the imbalanced and continuous use of chemical fertilizers in intensive cropping system has lead to reduction in the crop yields and resulted in imbalance of nutrient in soil which has adverse effect on soil bio-physico-chemical properties. The soil health and ecological hazards due to long term excessive use of chemical fertilizers also pose a serious problem. Although, chemical fertilizers are playing a crucial role to meet the nutrient requirement of the crop, the persistent nutrient depletion is posing a great threat to sustainable agriculture. The problem is so acute that, it is beyond the reach of any sole nutrient source to meet out the challenging nutrient requirement of the crop. Therefore, integrated use of both chemical fertilizers and organic manures is needed to check the depletion of soil health and enhance the yield levels.

On this backdrop there is need to evolve an appropriate agro-technology for successful cultivation of pigeonpea that results in efficient rain water conservation through land configuration use, growth regulators to get desired results and integrated nutrient management for higher productivity of above fact in view the present investigation entitled "Effect of land configuration, growth regulators and integrated nutrient management on growth and yield of pigeonpea" was carried out. A field experiment was carried out during *kharif* season of 2015-16 and 2016-17 at Experimental farm, AICRP on Integrated Farming Systems, VNMKV, Parbhani (M.S.)

MATERIALS AND METHODS

The experiments were conducted at experimental farms of AICRP on Integrated Farming Systems, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) during *kharif* season of 2015-16 and 2016-17. The topography of the experimental field was fairly uniform and levelled. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction, but marginally high in available potassium. The climate of Parbhani is semi-arid and characterized by three distinct seasons *viz.*, summer being hot and dry during March to May, warm and humid monsoon in June to October and winter with mild cold from November to February. Most of the rainfall received from south-west monsoon during June to October with mean annual normal precipitation of 964 mm received in 66.84 rainy days.

Treatment consists of twenty four treatment combinations comprising three land configurations and two foliar applications in main plot whereas, four integrated nutrient levels in sub plot. The treatments were allotted randomly in each replication. Main plot Land Configuration L_1:Flat bed L_2:Ridges and furrow L_3 Broad Bed Furrow, Foliar Application F_1: Foliar application of Mepiquat chloride @ 100 ppm at 50% flowering F_2:Foliar application of Cycocel @ 50 ppm at 50% flowering Sub plot Integrated Nutrient Management N_1:100% RDF + *Rhizobium* + PSB N_2:75% RDF + 2.5 t FYM ha^{-1} + *Rhizobium* + PSB N_3:50% RDF + 5 t FYM ha^{-1} + *Rhizobium* + PSB N_4: RDN through 1/3 FYM + 1/3 Vermicompost + 1/3 Neem cake + *Rhizobium* + PSB. The treatments were assigned in split plot design.

Certified seed for each crop under experimentation was used. Sowing was done by drilling method. The seed used for Pigeonpea c.v. BSMR-736. The distance in between two rows was 90 cm and in between two plants was 20.The recommended dose of fertilizer (RDF) used for Pigeonpea was 25: 50: 25 kg N, P_2O_5 and K_2O ha^{-1} respectively. The well decomposed FYM was applied uniformly before sowing in the respective plots as per the treatment specifications. The foliar application of mepiquat chloride @ 100 ppm and cycocel @ 50 ppm was done at 50% flowering stage of pigeonpea crop. The foliar application of plant growth regulators was done by knapsack sprayer with capacity of 15 litres.

Pigeonpea is grown as rainfed crop; therefore, it does not require any irrigation but in case of dry spell one or two life saving irrigation were given. Each net plot were selected randomly to represent the population in each b plot and labelled for recording growth observations. Various observations were recorded on these plants periodically after 30 days of sowing at an interval of 30 days till maturity of the crops, respectively. Observations on yield components were recorded after harvest of crop.

RESULTS AND DISCUSSION

The broad bed furrow produced significantly higher seed yield (1423, 1776 and 1600 kg ha^{-1}) over flat bed and it was found at par with ridges and furrow. The ridges and furrow method was next best land configuration method which produced significantly higher seed yield (1312, 1658 and 1485 kg ha^{-1}) as compared to flat bed method. Flat bed (1044, 1329 and 1187 kg ha^{-1}) recorded

Table 1: Mean seed yield and straw yield of pigeonpea as influenced by different treatments during 2015-16, 2016-17 & pooled

Treatments	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Biological yield (kg ha^{-1})		Harvest index	
Main Plot-Land configuration	**2015-16**	**2016-17**	**Pooled Mean**	**2015-16**	**2016-17**	**Pooled Mean**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
L_1 – Flat bed	1044	1329	1187	3148	3744	3446	4192	5074	24.90	26.19
L_2 – Ridges and furrow	1312	1658	1485	3644	4234	3939	4956	5893	26.47	28.13
L_3 – Broad bed furrow	1423	1776	1600	3747	4367	4057	5170	6144	27.52	28.90
SEm (±)	**35.32**	**36.96**	**40.30**	**56.15**	**70.59**	**61.61**	**60.13**	**74.54**	-	-
LSD (0.05)	**128.42**	**134.20**	**116.49**	**203.87**	**256.28**	**179.91**	**218.62**	**270.97**	-	-
Foliar application										
F_1 – Foliar application of mepiquat chloride @ 100 ppm at 50% flowering	1336	1660	1498	3334	3929	3631	4670	5589	28.60	29.70
F_2 – Foliar application of cycocel @ 50 ppm at 50% flowering	1183	1516	1349	3692	4302	3997	4876	5818	24.26	26.05
SEm (±)	**28.84**	**30.18**	**29.18**	**45.85**	**57.64**	**49.98**	**49.10**	**60.86**	-	-
LSD (0.05)	**104.71**	**109.5**	**84.34**	**166.46**	**209.25**	**145.96**	**179.21**	**222.13**	-	-
Sub Plot-Integrated Nutrient Management										
N_1 – 100% RDF+ *Rhizobium* + PSB	1230	1554	1392	3452	4085	3768	4682	5640	26.27	27.55
N_2 – 75% RDF + 2.5 t FYM ha^{-1} + *Rhizobium* + PSB	1284	1632	1460	3569	4169	3869	4854	5805	26.45	28.11
N_3 – 50% RDF + 5 t FYM ha^{-1} + *Rhizobium* + PSB	1467	1821	1644	3885	4389	4127	5354	6211	27.40	29.31
N_4 – RDN through 1/3 FYM+ 1/3 vermicompost + 1/3 neem cake + *Rhizobium* + PSB	1056	1342	1199	3145	3817	3481	4202	5159	25.13	26.01
SEm (±)	**44.06**	**49.02**	**46.21**	**76.74**	**88.26**	**80.74**	**83.03**	**100.48**	-	-
LSD (0.05)	**130.72**	**145.45**	**133.56**	**227.67**	**261.85**	**235.76**	**246.84**	**298.55**	-	
L × F Interaction										
SEm (±)	**49.95**	**52.28**	**55.48**	**79.41**	**99.83**	**87.86**	**85.05**	**105.41**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
L × N Interaction										
SEm (±)	**76.32**	**84.91**	**83.51**	**132.92**	**152.88**	**141.14**	**143.90**	**174.04**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
F × N Interaction										
SEm (±)	**62.31**	**69.33**	**65.49**	**108.53**	**124.82**	**114.91**	**117.49**	**142.10**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
L × F X N Interaction										
SEm (±)	**107.93**	**120.09**	**118.17**	**187.98**	**216.20**	**200.33**	**203.50**	**246.13**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
General Mean	**1259**	**1587**	**1424**	**3512**	**4115**	**3813**	**4772**	**5703**	**26.33**	**27.77**

Table 2: Economics of pigeonpea as influenced by different treatments during 2015-16, 2016-17 and pooled

Treatments	Gross monetary returns (Rs ha^{-1})			Net monetary returns (Rs ha^{-1})			B:C ratio	
Main Plot-Land configuration	**2015-16**	**2016-17**	**2015-16**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**
L_1 – Flat bed	54307	69021	61664	18618	33332	25975	1.53	1.94
L_2 – Ridges and furrow	68102	85874	76988	30814	48585	39700	1.83	2.31
L_3 – Broad bed furrow	73745	91907	82826	36857	55019	45938	2.00	2.50
SEm (±)	**1779.1**	**1854.4**	**1816.3**	**1770.4**	**1861.8**	**1815.4**	-	-
LSD (0.05)	**6458.5**	**6731.9**	**5249.1**	**6436.3**	**6768.4**	**5246.5**	-	-
Foliar application								
F_1 – Foliar application of mepiquat chloride @ 100 ppm at 50% flowering	69165	85816	77490	32588	49240	40914	1.89	2.35
F_2 – Foliar application of cycocel @ 50 ppm at 50% flowering	61604	78718	70161	24938	42051	33495	1.68	2.15
SEm (±)	**1452.6**	**1514.1**	**1482.9**	**1445.5**	**1520.1**	**1482.0**	-	-
LSD (0.05)	**5273.3**	**5496.5**	**4285.5**	**52.55.2**	**5526.3**	**4282.9**	-	-
Sub Plot-Integrated Nutrient Management								
N_1 – 100% RDF+ *Rhizobium* + PSB	63859	80527	72193	27490	44158	35824	1.75	2.21
N_2 – 75% RDF + 2.5 t FYM ha^{-1} + *Rhizobium* + PSB	66672	84668	75670	30450	48445	39448	1.84	2.33
N_3 – 50% RDF + 5 t FYM ha^{-1} + *Rhizobium* + PSB	76070	94188	85129	39994	58111	49053	2.10	2.61
N_4 – RDN through 1/3 FYM+ 1/3 vermicompost + 1/3 neem cake + *Rhizobium* + PSB	54936	69686	62311	17118	31868	24493	1.45	1.84
SEm (±)	**2242.3**	**2492.2**	**2366.8**	**2218.3**	**2475.8**	**2365.9**	-	-
LSD (0.05)	**6652.0**	**7393.5**	**6840.0**	**6590.9**	**7356.1**	**6837.4**	-	-
L X F Interaction								
SEm (±)	**2516.0**	**2622.5**	**2568.8**	**2503.8**	**2633.1**	**2567.9**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
L X N Interaction								
SEm (±)	**3883.8**	**4316.7**	**4099.8**	**3842.2**	**4288.2**	**4098.9**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
F X N Interaction								
SEm (±)	**3171.1**	**3524.5**	**3347.3**	**3137.1**	**3501.3**	**3346.5**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
L X F X N Interaction								
SEm (±)	**5492.5**	**6104.7**	**5798.1**	**5433.7**	**6064.4**	**5797.3**	-	-
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	-	-
General Mean	**65384**	**82267**	**73825**	**28763**	**45645**	**37205**	**1.62**	**2.04**

significantly lower seed yield as compared to rest of the land configuration treatments during both the year (Table 1) of experimentation and in pooled mean, respectively.

Foliar application of mepiquat chloride @ 100 ppm at 50% flowering (F_1) produced 1336, 1660 and 1498 kg ha^{-1} seed yield in 2015-16, 2016-17 and in pooled mean, respectively and it was found significantly higher than foliar application of cycocel @ 50 ppm at 50% flowering (F_2) during both (Table 1) the years and in pooled analysis.

Among the integrated nutrient management treatments, application of 50% RDF + 5 t FYM ha^{-1} + *Rhizobium* + PSB (N_3) produced maximum and significantly higher seed yield (1467 and 1821 kg ha^{-1}) over rest of the treatments during year 2015-16 and 2016-17, respectively. Application of 75% RDF + 2.5 t FYM ha^{-1} + *Rhizobium* + PSB (N_2) and 100% RDF + *Rhizobium* + PSB (N_1) remained at par with each other and both the treatments produced significantly higher seed yield over RDN through 1/3 FYM + 1/3 vermicompost + 1/3 neem cake + *Rhizobium* + PSB (N_4) during both the years.

Ridges and furrow method produced higher straw yield (3644, 4234 and 3939 kg ha^{-1}) over flat bed (3148, 3744 and 3446 kg ha^{-1}). However, the broad bed furrow and ridges and furrow methods were found to be at par with each other during both the years and pooled mean. (L3) recorded significantly higher biological yield (5170 and 6144 kg ha^{-1}) followed by ridges and furrow (L_2) which were found at par with each other but found significantly superior over flat bed method (L_1) in that descending order of significance.

Application of cycocel @ 50 ppm at 50% flowering (F_2) showed higher straw yield in 2015-16 (3692 kg ha^{-1}), 2016-17 (4302 kg ha^{-1}) and in pooled analysis (3997 kg ha^{-1}) and it was significantly superior to foliar application of mepiquat chloride @ 100 ppm at 50% flowering (F_1) in both the years and in pooled analysis Treatment of foliar application of Cycocel @ 50 ppm at 50% flowering (F_2) in pigeonpea recorded biological yield of 4876 and 5818 kg ha^{-1} in 2015-16 and 2016-17, respectively and it was found significantly higher than foliar application of Mepiquat chloride @ 100 ppm at 50% flowering (F_1) in both the years (Table 1).

Pigeonpea supplied with of 50% RDF + 5 t FYM ha^{-1} + *Rhizobium* + PSB (N_3) produced maximum and significantly higher straw yield (3885, 4389 and 4127 kg ha^{-1}) over rest of the integrated nutrient management treatments during both the years and in pooled mean. Application of 75% RDF + 2.5 t FYM ha^{-1} + *Rhizobium* + PSB (N_2) and 100% RDF + *Rhizobium* + PSB (N_1) were found to be at par with each other and both the treatments recorded significantly higher straw yield than RDN through 1/3 FYM + 1/3 vermicompost + 1/3 neem cake + *Rhizobium* + PSB (N_4) during both the years. Similar trend noticed about harvest index.

Broad bed furrow (L_3) fetch higher gross , net return and B:C ratio (2.00, 2.50 and 2.25) over rest of the land configuration treatments during both the years(Table 2) and in pooled mean. This may be due to better conservation of soil moisture and efficient utilization of stored soil moisture reflected in higher values of dry matter production and yield contributing characters. This resulted in significant improvement in seed and straw yield of pigeonpea under BBF treatment. Similar reports were also reported by Kadam (2015) and Kantawa *et al.,* (2016).

The trend of increased seed yield in foliar application treatment of Mepiquat chloride @ 100 ppm at 50% flowering (F_1) was observed in gross monetary returns (Rs. 69165, 85816 and 77490 ha^{-1}), net monetary returns (Rs. 32588, 49240 and 40914 ha^{-1}) which were significantly higher over foliar application of cycocel @ 50 ppm at 50% flowering (F_2) treatment during both the years and in pooled analysis (Table 2). The highest benefit cost ratio (1.89, 2.35 and 2.12) was recorded with the Mepiquat chloride @ 100 ppm at 50% flowering (F_1) during both the years and in pooled mean. This was mainly because of higher seed yield with growth regulator application. From the results it may be concluded that the growth regulator treatment mepiquat chloride @ 100 ppm at 50% flowering (F_1) was economically more remunerative than its counterpart treatment foliar application of Cycocel @ 50 ppm at 50% flowering (F_2). These findings are in close agreement with Kashyap *et al.,* (2002) and Kaur *et al.,* (2015).

Application of 50% RDF + 5 t FYM ha^{-1} + *Rhizobium* + PSB (N_3) gave maximum gross returns over rest of the integrated nutrient management treatments. These increased economic parameters were due to significant improvement in seed and straw yield of pigeonpea under integrated nutrient management treatment (N_3). Similar results were also reported by Ray *et al.* (2015) and Sahay *et al.* (2016).

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