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Response of Nutrient Management to Growth, Yield and Economics of Pigeonpea+Radish Intercropping System in Odisha

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Abstract

A field experiment was conducted to study the growth and productivity of pigeonpea + radish intercropping system under different nutrient management practices for two consecutive years during *kharif* seasons of 2013 and 2014 at Instructional Farm, RRTTS, Gumusur Udayagiri, OUAT, Kandhamal, Odisha, India. The treatments were Pigeonpea (100% RDF)+Radish (100% RDF), Pigeonpea (100% RDF)+Radish (75% RDF), Pigeonpea (100% RDF)+Radish (50% RDF), Pigeonpea (100% RDF)+Radish (25% RDF), Pigeonpea (100% RDF)+Radish (0% RDF), Pigeonpea (75% RDF)+Radish (100% RDF), Pigeonpea (50% RDF)+Radish (100% RDF), Pigeonpea (25% RDF)+Radish (100% RDF), Pigeonpea (0% RDF)+Radish (100% RDF), Pigeonpea (0% RDF)+Radish (0% RDF) as control, sole Pigeonpea (100% RDF) and Sole Radish (100% RDF). The twelve treatments were replicated thrice in a randomized block design. Among the intercropping systems, the treatment 100% RDF was applied to the base crop (pigeonpea) and 100% RDF to the intercrop (radish) almost all the growth parameters as well as yield components showed highest values. Sole crop of pigeonpea with 100% RDF produced the highest seed yield (1.20 t ha^{-1}) and stover yield (4.56 t ha^{-1}). Sole radish crop with 100% RDF achieved the highest root yield (17.70 t ha^{-1}) and leaf yield (4.02 t ha^{-1}) over other treatments followed by pigeonpea + radish with 100% RDF to base crop+100% RDF to intercrop. Sole radish exhibited the highest net return (₹ 73773 ha^{-1}) and return $rupee^{-1}$ investment (3.28) with 100% RDF though the highest gross return (₹ 125890 ha^{-1}) was obtained from pigeonpea +radish intercropping system with 100% RDF to both the crops.

Keywords: Pigeonpea, radish, intercropping, recommended dose, yield

1. Introduction

Pigeonpea an important crop amongst pulses is relatively less yielder because of its slow initial growth rate and low harvest index; therefore it is grown as intercrop which helps in efficient utilization of available resources for enhancing the productivity and profitability (Rao and Willey, 1980). In India, it is grown in an area of 5.40 m ha with an annual production of 4.78 mt and productivity of 885 kg ha^{-1} (Anonymous, 2017). The species of contrasting habit, both morphologically and physiologically would together be able to exploit the total environment more effectively than monoculture (Donald, 1963), though there is a significant amount of intercrop competition (Willey, 1979). Beets (1982) reported that crop insurance was a major principle of intercropping system. The competitive

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ability of intercropping was enhanced by the high plant population pressure provided by the component species together (Rao and Shetty, 1976). Intercropping system as a whole intercepts more solar radiation and thus has higher potential for photosynthesis than single crop stands (Reddy and Reddy, 1981). Thakur et al. (1998) reported that the intercrop entails better utilization of soil moisture, nutrients and solar radiation than sole cropping. Further it augments the utilization of available resources, viz., light, nutrients and moisture, with reference to the production per unit of applied inputs (Ahlawat et al., 2005). This significantly not only influence yield of intercrops (Reddy et al., 2007), but it would ensure low yield fluctuations than sole cropping even under unfavourable conditions (Anderson and Williams, 1954; Oguntowara and Norman, 1974). Pigeonpea offers a good scope for intercropping with fast growing early maturing and shallow rooted crops. Intercropping of pigeonpea with suitable intercrops brings stability in the yield and improves the total production. Aiyer (1949) reported that the resources with regard to plant nutrients present in the soil or added to it as manures were utilized to the fuller extent in mixed stand than when component crops were grown separately. Singh and Singh (1992) had reported that the production efficiency of pigeonpea is higher when it is grown as intercrop rather than the sole crop. Radish is easily grown as a companion crop or intercrop between the rows of tall growing pulses. Radish is a popular choice for cultivation, as they are fairly easy to grow and is a rapidly maturing crop with many varieties, and reach maturity within 60 days. Radish is useful in the treatment of liver, gall bladder troubles, sleeplessness, chronic diarrhoea, neuralgic headaches, urinary complaints, piles and gastrodynia (Sadhu, 1993). There is no need of irrigation for radish if sown in rainy season. To reduce the drought risks, pigeonpea+radish intercropping system has been recommended for the rainfed areas (Behera et al., 1998). The system maximizes the yield per unit area in good rainfall years and stabilizes the yield by minimizing the drought risks in bad rainfall years. With this view, the present experiment was carried out to study the nutrient management on growth, yield and economics of pigeonpea+radish intercropping system in Odisha.

2. Materials and Methods

The field experiment was conducted at Instructional Farm, Regional Research and Technology Transfer Station (RRTTS), Gumusur Udayagiri, Odisha University of Agriculture and Technology, district Kandhamal, Odisha state, India during *kharif* seasons, 2013 and 2014. The experiment consisted of twelve treatments (ten paired row arrangements 30/90 cm and sole crop of pigeonpea and radish) each with three replications was laid out in randomized block design (RBD). The treatments were T_1- Pigeonpea (100% RDF)+Radish (100% RDF), T_2- Pigeonpea (100% RDF)+Radish (75% RDF), T_3- Pigeonpea (100% RDF)+Radish (50% RDF), T_4- Pigeonpea (100% RDF)+Radish (25% RDF), T_5- Pigeonpea (100% RDF)+Radish (0% RDF), T_6- Pigeonpea (75% RDF)+Radish (100% RDF),T_7- Pigeonpea (50% RDF)+Radish (100% RDF), T_8- Pigeonpea (25% RDF)+Radish (100% RDF), T_9- Pigeonpea (0% RDF)+Radish (100% RDF), T_{10}- Pigeonpea (0% RDF)+Radish (0% RDF) Control, T_{11}-Sole Pigeonpea (100% RDF) and T_{12}-Sole Radish (100% RDF). The research location has an average annual rainfall of 128.69 cm. The soil was sandy loam in texture with pH, 5.4, organic carbon-0.39%, available N, 240.80 kg ha^{-1}, available P_2O_5, 22.0 kg ha^{-1} and available K_2O, 215.34 kg ha^{-1}. Pigeonpea *cv.* UPAS-120 and radish *cv.* Pusachetki were sown on 21 June, 2013 and 22 June, 2014, respectively in specified pigeonpea with spacing of 60×30 cm^2 in pigeonpea with 20 kg of seed ha^{-1} and 30×15 cm^2 in radish with 15 kg of seed ha^1 and all farm operations were conducted as per recommendations of the crops. The required quantities of fertilizers were applied as per the treatments with the area occupied by the component crop. Pigeonpea was harvested on 21 October, 2013 and 22 October, 2014 andradish on 07 August, 2013 and 09 August, 2014. Observations on growth and yield attributes were recorded periodically and yield was recorded at harvest of crops. The data were tabulated and analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984) and the significance of treatments was tested by 'F' test (Variance ratio).

3. Results and Discussion

3.1. Pigeonpea

3.1.1. Growth attributes

Sole pigeonpea ($P_{100\%}$ RDF) produced highest plant height (179 cm), number of primary branches plant^{-1} (17.3), dry matter accumulation(96.76 g plant^{-1}),crop grow rate (CGR) during 60–90 DAS (1.60 g plant^{-1} day^{-1}) and LAI at 90 DAS (4.64) on pooled data basis. Among the intercropping systems, the highest plant height (174.9 cm), number of primary branches plant^{-1} (15.3), LAI at 90 DAS (4.39), dry matter accumulation (95.47 g plant^{-1}) and CGR during 60–90 DAS (1.59 g plant^{-1} day^{-1}) of pigeonpea was recorded with $P_{100\%}$ RDF+$R_{100\%}$ RDF and this was followed by the treatment $P_{75\%}$ RDF+$R_{100\%}$ RDF,$P_{50\%}$ RDF+$R_{100\%}$ RDF and $P_{100\%}$ RDF+$R_{75\%}$ RDF. These results were in conformity with the findings of Parmila Rani and Reddy (2010), Kumawat et al. (2013), Nagar et al. (2015). Pal et al. (2015), Nagar et al. (2016).

3.1.2. Yield components and Yield

Sole pigeonpea receiving 100% RDF showed highest number of filled pods plant^{-1} (135.3), number of seeds pod^{-1} (5.0) and 1000-seed weight (82.16 g).This was at par with the intercropping systems with $P_{100\%}$ RDF+$R_{100\%}$ RDF and $P_{75\%}$ RDF+$R_{100\%}$ RDF. Similar results were recorded by Malik et al. (2013) and Pandey et al. (2013) (Table 1).

Sole pigeonpeawith 100% RDF produced highest seed yield of 1.20 t ha^{-1} and stover yield of 4.56 t ha^{-1} and was at par with full dose of fertilizers to $P_{100\%}$ RDF+$R_{100\%}$ RDF withseed yield of 1.16 t ha^{-1}and stover yield of 4.36 t ha^{-1}and superior to other treatments.Similar results have been reported by

Table 1: Response of nutrient management on growth, yield attributes and yields of pigeonpea in pigeonpea+radish intercropping system (Pooled data of two years)

Treatment	Pigeonpea									
	Growth attributes					Yield components			Yield	
	Plant height (cm) at harvest	LAI At 90 DAS	DMA (g plant^{-1}) at harvest	CGR (g plant^{-1} day^{-1}) 60-90 DAS	No. of branches plant^{-1} at harvest	No. of filled pods Plant^{-1}	No. of seeds Pod^{-1}	1000-Seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
$P_{100\%}$ RDF+ $R_{100\%}$ RDF	174.9	4.39	95.47	1.59	15.3	132.3	4.7	82.11	1.16	4.36
$P_{100\%}$ RDF+$R_{75\%}$ RDF	166.4	4.24	92.29	1.57	14.1	125.7	4.6	81.55	1.10	4.20
$P_{100\%}$ RDF+$R_{50\%}$ RDF	156.1	4.14	87.65	1.56	13.1	116.5	4.4	81.25	0.93	3.96
$P_{100\%}$ RDF+$R_{25\%}$ RDF	151.5	4.13	86.08	1.56	12.7	115.5	4.3	81.20	0.92	3.95
$P_{100\%}$ RDF+$R_{0\%}$ RDF	146.4	4.06	78.79	1.55	11.6	110.9	4.4	81.12	0.86	3.79
$P_{75\%}$ RDF+$R_{100\%}$ RDF	170.4	4.33	94.82	1.59	14.6	130.3	4.7	82.10	1.11	4.22
$P_{50\%}$ RDF+$R_{100\%}$ RDF	169.2	4.26	93.42	1.57	14.5	127.8	4.6	81.98	1.10	4.21
$P_{25\%}$ RDF+$R_{100\%}$ RDF	165.2	4.20	91.53	1.56	14.0	122.7	4.5	81.78	1.03	4.04
$P_{0\%}$ RDF+$R_{100\%}$ RDF	161.2	4.16	88.99	1.56	13.5	120.4	4.5	81.34	0.99	4.02
$P_{0\%}$ RDF+$R_{0\%}$ RDF	129.3	3.35	73.22	1.03	10.7	84.6	4.1	80.10	0.44	1.97
Sole pigeonpea ($P_{100\%}$ RDF)	179.0	4.64	96.76	1.60	17.3	135.3	5.0	82.16	1.20	4.56
Sole radish ($R_{100\%}$ RDF)	-	-	-	-	-	-	-	-	-	-
SEm±	5.20	0.05	2.09	0.027	0.46	2.78	0.22	1.65	0.029	0.084
CD (*p*=0.05)	10.78	0.10	4.33	0.080	0.95	5.77	0.46	NS	0.060	0.174

P: Base crop (Pigeonpea); R: Intercrop (Radish); RDF of pigeonpea-20-40-20 of N: P_2O_5:K_2O in kg ha^{-1}; RDF of radish-50:50:75 of N:P_2O_5:K_2O in kg ha^{-1}

Vishwanatha et al. (2012).

3.2. Radish

3.2.1 . Growth attributes

Sole radish with application of 100% RDFrecorded highest plant height (43.0 cm), number of leaves plant^{-1} (15.22),LAI (1.49); dry matter accumulation (56.21 g plant^{-1}) and CGR at 20-30 DAS (1.58 g plant^{-1} day^{-1}). This was followed by intercropping system with $P_{100\%}$ RDF+R $_{100\%}$ RDF with plant height of 37.2 cm, number of leaves plant^{-1} 12.2, LAI of 1.28, dry matter accumulation of 45.1 g plant^{-1}. The treatment with pigeonpea+radish intercropping system having no fertilizers resulted in lowest plant height (21.1 cm), number of leaves plant^{-1} (5.73), leaf area index (0.53),dry matter accumulation (25.83 g plant^{-1}) and CGR (0.68 g plant^{-1} day^{-1}) in pooled analysis. These results were in accordance with the findings of Brintha and Seran (2009).

3.2.2. Yield components and yield

Highest value of root length (29.01 cm) and root girth (13.0cm) was recorded with sole radish ($R_{100\%}$ RDF) which was significantly higher than all other treatments. Among the intercropping systems, $P_{100\%}$ RDF+$R_{100\%}$ RDFresulted higher value of root length (22.8 cm) andgirth of roots (9.82 cm) and it was followed by $P_{75\%}$ RDF+$R_{100\%}$ RDF and $P_{50\%}$ RDF+R $_{100\%}$ RDF which were found to be at par.These results were in conformity with the findings of Brintha and Seran (2009) and Thavaprakaash et al. (2005).

The highest root yield (17.70 t ha^{-1}) and leaf yield (4.02 t ha^{-1}) of radish was obtained fromsole crop of radish with 100% RDF and was significantly higher than all other intercropping treatments. Among the intercropping systems, application of 100% RDF to base crop+100% RDF to intercrop resulted in higher root yield of radish (13.22t ha^{-1})and leaf yield (3.71 t ha^{-1}) followed by $P_{75\%}$ RDF+$R_{100\%}$ RDF.Similar results were reported by Brintha and Seran (2009) and Islam et al. (2011) (Table 2).

4. Economics

The highest net returns (₹ 73773 ha^{-1}), return rupee^{-1} investment (3.28) was achieved from the treatment where 100% RDF was applied to sole radish.This was followed by intercropping system with 100% RDF to base crop+100% RDF to intercrop (net return of ₹ 71915 ha^{-1} and return rupee^{-1} investment of 2.33). The highest gross return was obtained from intercropping system of $P_{100\%}$ RDF+$R_{100\%}$ RDF (₹ 1, 25,890) followed by $P_{75\%}$ RDF+$R_{100\%}$ RDF and $P_{50\%}$ RDF+$R_{100\%}$ RDF These findings were in accordance with the results reported by Kasbe and Karanjikar (2009) and Vishwanatha et al. (2012) (Table 3).

Table 2: Response of nutrient management on growth, yield attributes and yields of radish in pigeonpea+radish intercropping system (Pooled data of two years)

Treatment	Radish								
	Growth attributes					Yield components			Yield
	Plant height (cm) at harvest	No. of leaves Plant^{-1} at harvest	LAI at harvest	DMA (g plant^{-1}) at harvest	CGR (g plant^{-1} day^{-1}) 20-30 DAS	length of root (cm)	Girth of root (cm)	Root yield (t ha^{-1})	Leaf yield (t ha^{-1})
$P_{100\%}$ RDF+$R_{100\%}$ RDF	37.2	12.2	1.28	45.10	1.25	22.8	9.8	13.22	3.71
$P_{100\%}$ RDF+$R_{75\%}$ RDF	34.4	10.1	1.05	43.43	1.20	21.7	9.3	11.86	3.38
$P_{100\%}$ RDF+$R_{50\%}$ RDF	29.5	8.6	0.92	40.65	1.05	21.2	9.0	10.59	2.82
$P_{100\%}$ RDF+$R_{25\%}$ RDF	28.7	8.0	0.91	40.08	1.04	20.7	8.9	10.51	2.76
$P_{100\%}$ RDF+$R_{0\%}$ RDF	26.6	7.6	0.87	38.42	0.99	20.0	8.6	10.30	2.33
$P_{75\%}$ RDF+$R_{100\%}$ RDF	35.5	11.0	1.07	44.38	1.26	22.1	9.5	12.23	3.53
$P_{50\%}$ RDF+$R_{100\%}$ RDF	34.6	10.6	1.07	44.10	1.24	21.9	9.3	11.98	3.46
$P_{25\%}$ RDF+$R_{100\%}$ RDF	32.5	9.6	0.98	42.74	1.16	21.5	9.1	11.29	3.23
$P_{0\%}$ RDF+$R_{100\%}$ RDF	31.5	8.8	0.94	41.41	1.12	21.6	9.1	10.87	3.03
$P_{0\%}$ RDF+$R_{0\%}$ RDF	21.1	5.7	0.53	25.83	0.68	12.9	5.2	4.28	1.48
Sole pigeonpea ($P_{100\%}$ RDF)	-	-	-	-	-	-	-	-	-
Sole radish ($R_{100\%}$ RDF)	43.0	15.2	1.49	56.21	1.58	29.0	13.0	17.70	4.02
SEm±	1.70	0.47	0.04	0.45	0.044	0.47	0.39	0.57	0.10
CD (*p*=0.05)	3.53	0.97	0.08	0.93	0.128	0.97	1.14	1.19	0.21

Table 3: Response of nutrient management on economics in pigeonpea and radish intercropping system (Pooled data of two years)

Treatment		Economics			
		Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	Return rupee^{-1} investment (₹)
T_1	$P_{100\%}$ RDF+$R_{100\%}$ RDF	37.2	12.2	1.28	45.10
T_2	$P_{100\%}$ RDF+$R_{75\%}$ RDF	34.4	10.1	1.05	43.43
T_3	$P_{100\%}$ RDF+$R_{50\%}$ RDF	29.5	8.6	0.92	40.65
T_4	$P_{100\%}$ RDF+$R_{25\%}$ RDF	28.7	8.0	0.91	40.08
T_5	$P_{100\%}$ RDF+$R_{0\%}$ RDF	26.6	7.6	0.87	38.42
T_6	$P_{75\%}$ RDF+$R_{100\%}$ RDF	35.5	11.0	1.07	44.38
T_7	$P_{50\%}$ RDF+$R_{100\%}$ RDF	34.6	10.6	1.07	44.10
T_8	$P_{25\%}$ RDF+$R_{100\%}$ RDF	32.5	9.6	0.98	42.74
T_9	$P_{0\%}$ RDF+$R_{100\%}$ RDF	31.5	8.8	0.94	41.41
T_{10}	$P_{0\%}$ RDF+$R_{0\%}$ RDF	21.1	5.7	0.53	25.83
T_{11}	Sole pigeonpea ($P_{100\%}$ RDF)	-	-	-	-
T_{12}	Sole radish ($R_{100\%}$ RDF)	43.0	15.2	1.49	56.21
	SEm±	1.70	0.47	0.04	0.45
	CD (*p*=0.05)	3.53	0.97	0.08	0.93

5. Conclusion

Sole crop of radish with 100% RDF produced the highest yield (17.70 t ha^{-1}), net return (₹ 73773 ha^{-1}) and return $rupee^{-1}$ investment (3.28) when compared with other intercropping systems. Among different intercropping systems application of 100% recommended fertilizer dose with pigeonpea and radish performed best.

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