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Growth and Yield Response of Finger Millet under Varying Plant Density and Organic Nutrient Management Practices and their Residual Effect on Green Pea

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A B S T R A C T

An experiment was conducted at Birsa Agricultural University, Ranchi during 2017-18 and 2018-19 for Finger millet-Green pea cropping system under two factors viz., different seed rates and organic nutrient managements for finger millet and its residual effect with 50% nutrition in succeeding green pea. Results revealed that growth parameters, yield attributes, yield and economics of finger millet were significantly influenced by different treatments of seed rate and organic nutrient management. In finger millet, plant height at 90 DAS(73.33 cm), LAI at 60 DAS (2.78) and dry matter accumulation per m^2 at harvest (815.8 g) were maximum with125% seed rate and 100% N through vermicompost. Yield attributes namely, effective tillers per m^2 (66.53), number of fingers per ear (7.07), ear weight (7.23 g), test weight (3.61 g), number of grains per ear (2751), grain yield (25.17 q/ha) and straw yield (44.57 q/ha) of finger millet were also recorded maximum in the same treatment.

Introduction

Finger millet, commonly known as *ragi*, is grown extensively in various regions of India. It is used as staple food that supplies a major portion of calories and protein for people of low-income group. Finger millet is generally taken in uplands in Jharkhand where they perform poorly due to low soil fertility as well as poor plant stand under direct sowing conditions. In recent decades, emphasis has been shifted from individual crop to cropping system because responses in component crops are influenced by the nutrient application to preceding crops by leaving substantial effect on the succeeding crop as carry over benefit. Also, taking two crops in a sequence, or intensive cropping in place of mono-cropping in uplands like inclusion of pulses in crop sequence is agronomically very significant. Pea (*Pisumsativum L.*) is a good predecessor to other crop as it enriches the soil with the nodule bacteria which leave in its roots and fix nitrogen in soil which becomes available

to next plant (Rudnicki and Wenda 2002). Moreover, pea has a higher capacity to utilize minerals (inorganic compounds) which are difficult to assimilate and therefore practically not available for cereals (Adgo and Schulze 2002). The root system of pea penetrates to a depth of 1-1.5 m and as a result, unlike grain crops, pea can extract nutrients from the deeper soil layers (Vocanson *et al.,* 2006). In recent years, the value of peas for fodder purposes has increased (its green matter contains 14 to 24% proteins, averaging 16%) as well as its value as a vegetable crop (green peas are the high protein-containing vegetables with a protein content of 6-7% on the fresh weight basis). It is grown as Rabi vegetable. It has been suggested that there is no need to apply fertilizers if moderate nutrient requiring crops like pea succeeds. Deleterious effect of chemical fertilizers in agriculture has led to adopt organic crop production as an alternative method which also maintains soil health and improves overall ecological balance of the production system. Thus, adopting combination of proper plant population and organic nutrient management can lead in better grain production. Information on seed rate in finger millet under organic nutrient management and its residual effect on second crop in sequence is very meager.

Materials and Methods

A field experiment was undertaken at Agronomy Research Fram, Birsa Agricultural University at Kanke, Ranchi during 2017-18 and 2018-19. The soil of the experimental site was acidic in reaction (pH 5.8), sandy loam in texture, low in organic carbon (0.37%), available nitrogen (250 kg/ha), available phosphorous () and available potassium (). The experiment was laid out in randomized block design (Factorial) with three replications. There seed rates viz., 100%, 125% and 150% along with different organic nutrient managements viz., control, 100% N through FYM, 100% N through vermicompost, 75% N through FYM + 25% N through vermicompost, 50% N through FYM + 50% N through vermicompost and 25% N through FYM + 75% N through vermicompost. Altogether the experiment comprised of eighteen treatments. The nutrients as per the treatments were applied in the soil at the time of sowing. Finger millet was direct sown in the month of June with row to row spacing of 30 cm. Growth parameters of the crop were recorded at intervals of 30 days and yield attributes were recorded at maturity and at the time of harvest. Finger millet was harvested in the month of November, after harvesting, the straw was incorporated into the soil with the help of power tiller. The pea was sown at spacing of 30 cm x 10 cm and was provided with only 50% N of RDF through vermicompost. Yield attributes and yield of green pea pods were recorded at maturity and after harvesting. Green pea pods were harvested for vegetable purpose thrice in the month of February. After completion of crop cycle, finger millet equivalent yield, system cost of cultivation, system gross return, system net return and system B:C ratio were calculated.

Results and Discussion

Growth parameters

Plant height, number of tillers/m^2, dry matter production and LAI increased with the age of plant. Vegetative growth parameters were recorded maximum at 125% seed rate with 50% N through FYM + 50% N through vermicompost being *at par* with 25% N through FYM + 75% N through vermicompost and 75% N through FYM + 25% N through vermicompost. Use of FYM alone resulted lower values than combination of FYM and vermicompost.

It was noted that plant height of finger millet at 30, 60, 90 DAS and at maturity was recorded maximum (33.05 cm), (59.59 cm), (67.55 cm) and (68.06 cm) with 125% seed rate than 150% & 100% (Table 1, 2, 3, 4). In case of organic nutrient management, 50% N through FYM + 50% N through vermicompost was found to be significantly better than other nutrient management practices and produced maximum plant height of 34.22 cm which was *at par* with 25% N through FYM + 75% N through vermicompost. Dry matter at 30, 60, and 90 DAS and at maturity, was recorded significantly maximum (75.26 g/m^2, 249.2 g/m^2, 537.1 g/m^2 and 778.06 g/m^2) with 125% seed rate than 150% and 100% seed rates (Table 5, 6, 7, 8). In case of organic nutrient management, 50% N through FYM + 50% N through vermicompost produced maximum dry matter (76.85 g/m^2), (255.5 g/m^2), (574.0 g/m^2) and (814.72 g/m^2)which was found to be significantly better than control. Interaction between seed rate and organic nutrient management was observed to be non significant. Values were observed the lowest in use of alone source (FYM).

Table.1 Plant height (cm) of finger millet at 30 DAS as influenced by plant density and organic nutrient management in finger millet - green pea cropping system. (Pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	**100% N FYM**	**100% N Vermi-compost**	**75% N FYM + 25% N VC**	**50% N FYM + 50% N VC**	**25% N FYM + 75% N VC**	**Mean**
100%	20.00	26.67	30.48	29.78	32.67	32.00	29.26
125%	24.99	30.46	31.67	31.37	36.33	34.33	33.05
150%	23.89	30.00	31.04	30.37	34.49	32.67	31.58
Mean	22.96	29.04	31.06	30.50	34.22	33.00	
Seed rate	SEm±	0.80	CD(P=0.05)	1.91			
Organic nutrient management	SEm±	1.13	CD(P=0.05)	2.69			
Interaction (A x B)	**SEm±**	**1.95**	**CD(P=0.05)**	**4.67**	**CV%**	**11.20**	

Table.2 Plant height (cm) of finger millet at 60 DAS as influenced by plant density and organic nutrient management in finger millet - green pea cropping system. (Pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	**100% N FYM**	**100% N Vermi-compost**	**75% N FYM + 25% N VC**	**50% N FYM + 50% N VC**	**25% N FYM + 75% N VC**	**Mean**
100%	38.00	56.87	58.77	57.83	60.00	59.95	53.90
125%	44.00	58.49	60.37	59.97	66.67	61.12	59.59
150%	48.67	57.51	59.42	58.77	61.05	60.12	57.77
Mean	45.56	57.62	59.52	58.86	62.57	60.40	
Seed rate	**Sem±**	1.38	**CD(P=0.05)**	2.77			
Organic nutrient management.	**Sem±**	1.95	**CD(P=0.05)**	3.95			
Interaction (A x B)	**Sem±**	**3.39**	**CD(P=0.05)**	**7.59**	**CV%**	10.11	

Table.3 Plant height (cm) of finger millet at 90 DAS as influenced by plant density and organic nutrient management in finger millet - green pea cropping system (Pooled data of 2 years)

Seed rate(A)	Organic Nutrient Management (B)						
	Control	**100% N FYM**	**100% NVermi-compost**	**75% N FYM + 25% N VC**	**50% N FYM + 50% N VC**	**25% N FYM + 75% N VC**	**Mean**
100%	50.00	60.00	63.00	56.00	69.11	66.00	60.01
125%	66.60	65.00	70.00	68.55	73.00	70.65	67.55
150%	59.00	61.05	67.15	66.85	70.43	68.22	65.07
Mean	50.20	63.11	65.01	64.33	69.15	68.03	
Seed rate	**Sem±**	1.22	**CD(P=0.05)**	3.33			
Organic nutrient management	**Sem±**	1.62	**CD(P=0.05)**	4.56			
Interaction (A x B)	**Sem±**	**4.98**	**CD(P=0.05)**	**7.00**	**CV%**	8.55	

Table.4 Plant height (cm) of finger millet at harvest as influenced by plant density and organic nutrient management in finger millet - green pea cropping system. (Pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	**100% N FYM**	**100% NVermi-compost**	**75% N FYM + 25% N VC**	**50% N FYM + 50% N VC**	**25% N FYM + 75% N VC**	**Mean**
100%	50.00	60.00	63.33	56.67	69.67	66.21	60.98
125%	66.67	65.41	70.73	69.11	73.33	71.03	68.06
150%	59.18	61.67	68.11	67.22	71.07	69.09	65.88
Mean	50.62	63.36	65.39	65.77	69.78	68.36	
Seed rate	**Sem±**	2.98	**CD(P=0.05)**	3.32			
Organic nutrient management	**Sem±**	3.01	**CD(P=0.05)**	5.44			
Interaction (A x B)	**Sem±**	**5.33**	**CD(P=0.05)**	**7.01**	**CV%**	8.75	

Table.5 Dry matter (g/m^2) of finger millet as influenced by plant density and organic nutrient management in finger millet - green pea cropping system (Pooled data of 2 years)

Treatment	30 DAS	60 DAS	90 DAS	At harvest
A. Seed rate				
100%	67.40	242.5	519.6	730.6
125%	75.26	249.2	537.1	798.0
150%	73.93	247.5	523.1	773.3
SEm±	1.78	8.22	18.86	14.77
CD (P=0.05)	4.24	19.6	45.08	35.3
B. Organic Manure levels				
Control	60.66	226.1	476.5	581.3
100% N through FYM	73.27	247.6	489.6	710.4
100% N through Vermicompost	75.55	249.7	536.3	772.5
75% N FYM + 25% N Vermicompost	72.24	248.6	533.0	761.3
50% N FYM + 50% N Vermicompost	76.89	255.5	574.0	814.7
25% N FYM + 75% N Vermicompost	74.57	250.7	550.1	803.4
SEm±	2.51	11.63	26.68	20.89
CD (P=0.05)	6.00	27.7	63.75	39.9
Interaction (A x B)	NS	NS	NS	NS
CV%	10.20	14.10	12.07	8.10

Table.6 Number of tillers/m^2 in finger millet at 60 DAS as influenced by plant density and organic nutrient management in finger millet - green pea cropping system (Pooled data of 2 years)

Treatment	Pooled (2 years)
A. Seed rate	
100%	58.11
125%	64.15
150%	59.33
SEm±	0.77
CD (P=0.05)	1.92
B. Organic Manure levels	
Control	49.17
100% N through FYM	56.88
100% N through Vermi-compost	58.26
75% N FYM + 25% N Vermi-compost	57.44
50% N FYM + 50% N Vermi-compost	65.84
25% N FYM + 75% NVermi-compost	60.95
SEm±	1.01
CD (P=0.05)	2.40
Interaction (A x B)	NS
CV%	11.24

Table.7 Number of tillers/m^2 in finger millet at 90 DAS as influenced by plant density and organic nutrient management in finger millet - green pea cropping system (Pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	100% N FYM	100% NVermi-compost	75% N FYM + 25% N VC	50% N FYM + 50% N VC	25% N FYM + 75% N VC	Mean
100%	42.33	61.00	63.66	62.56	65.78	63.11	59.74
125%	53.21	64.31	66.87	66.78	68.33	66.79	64.38
150%	54.55	63.47	64.66	64.91	66.12	65.54	63.20
Mean	50.03	62.92	65.06	64.75	66.74	65.14	
Seed Rate	**Sem+**	0.41	**CD(P=0.05)**	1.77			
Organic Nutrient Management	**Sem+**	0.59	**CD(P=0.05)**	1.89			
Interaction (A x B)	**Sem+**	**1.05**	**CD(P=0.05)**	**2.91**	**CV%**	9.55	

Table.8 Leaf Area Index of finger millet at 30 DAS as influenced by plant density and organic nutrient management in finger millet - green pea cropping system. (Pooled data of 2 years)

Treatment	30 DAS	60 DAS	90 DAS
A. Seed rate			
100%	0.58	1.52	2.50
125%	0.61	1.59	2.58
150%	0.60	1.57	2.55
SEm±	0.01	0.01	0.09
CD (P=0.05)	0.02	0.03	0.22
B. Organic Manure levels			
Control	0.48	1.33	1.85
100% N through FYM	0.59	1.58	2.64
100% N through Vermicompost	0.62	1.61	2.69
75% N FYM + 25% N Vermicompost	0.61	1.59	2.66
50% N FYM + 50% N Vermicompost	0.64	1.64	2.73
25% N FYM + 75% N Vermicompost	0.63	1.62	2.69
SEm±	0.01	0.02	0.13
CD (P=0.05)	0.03	0.04	0.32
Interaction (A x B)	NS	NS	NS
CV%	7.51	7.49	8.38

Table.9 Effective tillers/m^2 of finger millet at maturity as influenced by plant density and organic nutrient management in finger millet - green pea cropping system. (Pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	100% N FYM	100% NVermi-compost	75% N FYM + 25% N VC	50% N FYM + 50% N VC	25% N FYM + 75% N VC	Mean
100%	39.82	59.57	61.07	59.67	61.63	61.55	57.22
125%	49.53	63.33	64.80	64.42	66.53	65.07	62.28
150%	51.07	61.90	62.70	62.33	63.33	63.25	60.76
Mean	46.81	61.60	62.86	62.14	63.83	63.29	
Seed Rate	**Sem+**	0.45	**CD(P=0.05)**	1.08			
Organic Nutrient Management	**Sem+**	0.64	**CD(P=0.05)**	1.52			
Interaction (A x B)	**Sem+**	**1.10**	**CD(P=0.05)**	**2.64**	**CV%**	10.18	

Table.10 Ear weight (g), fingers/ear, grains/ear and 1000 grain weight (g) of finger millet at maturity as influenced by plant density and organic nutrient management in finger millet - green pea cropping system. (Pooled data of 2 years)

Treatment	Ear weight	Fingers/ ear	Grains/ear	1000 grain weight
A. Seed rate				
100%	6.60	5.71	2278	3.08
125%	6.78	6.60	2547	3.31
150%	6.70	6.38	2377	3.18
SEm±	0.17	0.10	36.92	0.05
CD (P=0.05)	0.41	0.24	88.22	0.12
B. Organic Manure levels				
Control	4.53	4.66	1866	2.66
100% N through FYM	7.08	6.36	2435	3.14
100% N through Vermicompost	7.12	6.56	2506	3.26
75% N FYM + 25% N Vermicompost	7.10	6.50	2481	3.27
50% N FYM + 50% N Vermicompost	7.18	6.68	2596	3.46
25% N FYM + 75% N Vermicompost	7.13	6.63	2521	3.36
SEm±	0.25	0.14	52.21	0.07
CD (P=0.05)	0.59	0.34	124.76	0.17
Interaction (A x B)	NS	NS	NS	NS
CV%	11.63	9.01	11.89	7.88

Table.11 Grain yield finger (q/ha) millet as influenced by plant density and organic nutrient management in finger millet - green pea cropping system (pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	100% N FYM	100% N Vermi-compost	75% N FYM + 25% N VC	50% N FYM + 50% N VC	25% N FYM + 75% N VC	Mean
100%	7.3	17.3	22.2	20.0	23.1	23.0	18.8
125%	7.9	19.0	24.3	21.5	25.1	24.8	20.4
150%	7.4	18.3	22.7	21.0	23.7	23.4	19.4
Mean	7.5	18.2	23.1	20.8	24.0	23.7	
Seed Rate	**Sem+**	0.42	**CD(P=0.05)**	1.01			
Organic Nutrient Management	**Sem+**	0.60	**CD(P=0.05)**	1.43			
Interaction (A x B)	**Sem+**	**1.04**	**CD(P=0.05)**	**2.48**	**CV%**	9.17	

Table.12 Straw yield finger millet (q/ha) as influenced by plant density and organic nutrient management in finger millet - green pea cropping system (pooled data of 2 years)

Seed rate (A)	Organic Nutrient Management (B)						
	Control	100% N FYM	100% N Vermi-compost	75% N FYM + 25% N VC	50% N FYM + 50% N VC	25% N FYM + 75% N VC	Mean
100%	31.4	33.3	40.0	33.3	44.5	42.5	37.8
125%	31.6	36.5	41.0	39.7	44.9	42.8	39.2
150%	28.5	34.7	38.8	**37.7**	40.4	39.8	36.7
Mean	30.5	34.8	40.2	36.9	43.3	40.9	
Seed Rate	**Sem+**	0.40	**CD(P=0.05)**	0.96			
Organic Nutrient Management	**Sem+**	0.57	**CD(P=0.05)**	1.35			
Interaction (A x B)	**Sem+**	**0.98**	**CD(P=0.05)**	**2.34**	**CV%**	7.40	

At 60 DAS, number of effective tillers/m^2 was recorded significantly maximum (64.15) with 125% seed rate than effective tillers with 150% & 100% seed rates (59.33 & 58.11, respectively). In case of organic nutrient management, 50% N through FYM and 50% N through vermin compost was found to be significantly superior to other nutrient doses and produced maximum number of effective tillers of 65.84 followed by 25% N through FYM + 75% N through vermicompost (60.95). Values were observed the lowest in use of alone source (FYM).

At 90 DAS, number of tillers/m^2 was recorded significantly maximum (64.38) with 125% seed rate than effective tillers with 150% & 100% seed rates (63.20 & 59.74, respectively). In case of organic nutrient management, 50% N through FYM + 50% N through vermicompost was found to be significantly better than other nutrient

managements and produced maximum number of tillers/m^2 (66.74). In case of interaction, 125% seed rate with 50% N through FYM + 50% N through vermicompost resulted significant maximum number of tillers/m^2 (68.33) being *at par* with125% seed rate with 25% N through FYM + 75% N through vermicompost. (66.79). Values were observed the lowest in use of alone source (FYM).

At 30 DAS, 60 DAS and at 90 DAS leaf area index was recorded significantly maximum (0.61. 1.59 and 2.58) with 125% seed rate than leaf area index with 150% & 100% seed rates. In case of organic nutrient management, 50% N through FYM + 50% N throughvermicompost was found to be significantly better than other nutrient managements and produced maximum leaf area index (0.64, 1.64 and 2.73) followed by 25% N through FYM + 75% N through vermicompost. Interaction between seed rate and organic nutrient management was observed to be non significant. Values were observed the lowest in use of alone source (FYM).

At maturity, number of effective tillers/m^2 was recorded significantly maximum (62.28) with 125% seed rate than effective tillers with 150% & 100% seed rates (60.76 & 57.22, respectively). In case of organic nutrient management, 50% N through FYM + 50% N through vermicompost was found to be significantly better than other nutrient managements and produced maximum number of effective tillers/m^2 (63.83). In case of interaction, 125% seed rate with 50% N through FYM + 50% N through vermicompost resulted significant maximum number of effective tillers/m^2 (66.53) being *at par* with125% seed rate with 25% N through FYM + 75% N through vermicompost. (65.07). Values were observed the lowest in use of alone source (FYM).

Ear weight (g), No. of fingers/ear, No. of grains/ear and 1000 grain weight were recorded significantly maximum (6.78 g, 6.60, 2547 and 3.31 g) with 125% seed rate than ear weight with 150% & 100% seed rates. In case of organic nutrient management, 50% N through FYM + 50% N through vermicompost was found to be significantly better than other nutrient managements and produced maximum ear weight of 7.18 g, 6.68, 2596 and 3.46 g. Interaction between seed rate and organic nutrient management was observed to be non significant. Values were observed the lowest in use of alone source (FYM).

Grain and straw yield of finger millet was recorded maximum (20.4 and 39.2 q/ha) with 125% seed rate than with 150% & 100% seed rates. In case of organic nutrient management, 50% N through FYM + 50% N through vermicompost was found to be significantly better than other nutrient managements and produced maximum grain and straw yield (24.0 and 43.3 q/ha).Interaction showed that 125% seed rate with 50% N through FYM + 50% N through vermicompost yielded maximum grain and straw yield 25.1 and 44.9 q/ha, which was *at par* with 125% seed rate along with 25% N through FYM + 75% N through vermicompost and125% seed rate along with 100% N through vermicompost.

Balanced combination of organic sources is indispensible to supplement nutrients in accordance with the demand of plants for ensuring higher production and productivity without having deleterious effect on soil health. Organic nutrient management showed its influence on grain and straw yield of finger millet. The crop produced significantly highest grain yield and straw yield at 125% seed rate with 50% N through FYM + 50% N through vermicompost (under pooled data) which was *at par* with 125% seed rate with

25% N through FYM + 75% N through vermicompost. Grain yield is related to the growth and yield attributes. All the growth parameters and yield attributes were higher with application of the combination of 50% N through FYM + 50% N through vermicompost. This might be because of increased as well as sustained supply, absorption and assimilation of nutrients. Supply of nitrogen and other nutrients at right time and quantity enable the plants to assimilate sufficient photosynthetic products and thus increased yield attributes and yield of the crop. With more dry photosynthetic products into dry matters coupled with efficient translocation, plants produce more panicles, number of filled grains with increased 1000 grain weight and finally higher grain yield (Das *et al.,* 2010). Organic manures besides supplying of nutrients, also bring an improvement towards physical properties of soil and thereby improving nutrient and water holding capacity (Bhardwaj and Gaur, 1985). Increased grain yield can also be result of the effect of adequate availability of nitrogen, phosphorus and potassium in soil solution to accelerate root growth and more uptake of nutrients. Higher yield due to combined application of organic manures might be attributed to sustained nutrient supply and also as a result of better utilization of applied nutrients through improved micro – environmental conditions, especially the activities of soil micro – organisms involved in nutrient transformation and fixation. Similar findings were also reported by Virdia and Mehta (2008) and Dhanushkodi and Kannathasan (2012).

On the basis of above results it may be concluded that application of 125% seed rate with50% N through FYM + 50% N through vermicompost in *kharif* finger millet and then in *rabi* green pea fed at50% N through vermicompost may be practiced under finger millet – green pea cropping sequence for higher productivity and profitability.

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