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Growth and Yield Analysis under Amaranth based Inter-cropping System

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Abstract: A field experiment conducted during 2018 and 2019 at AICRN Centre, Ranichauri, Uttarakhand, revealed that neither main crop nor inter-crops had any significant effect on the plant stand of each other. All the inter-crops adversely affected dry weight, number of fingers and weight of grains per plant of main crop of amaranth (*Amaranth* spp.) in 2018, while the trend was reverse in 2019. The grain yield of amaranth was decreased due to inter-cropping during both the years. The row arrangement of 1:1 ratio favoured most of the growth and yield characters of main crop. The highest amaranth equivalent (40.54 q/ha) and land equivalent ratio (1.60) were however recorded with horse gram (*Marcotyloma uniflorum*) when planted in 1:1 ratio.

Keywords: Amaranth, faba bean, rice bean, inter-cropping, land equivalent.

INTRODUCTION

Grain amaranth is a potential underutilized crop known for its nutritive grain. In the recent past, it has emerged as one of the important health care crop because of its high protein and minerals in the grain with high lysine content in the protein. Though, it is considered as crop of food and nutritional security, its cultivation is very limited both at global and national level and its full potential has not been exploited. For any underutilized potential crop species, the first step is to popularize the crop with farmers, creating market potential and to create awareness with the consumers about the nutritional benefits of crop . As there is limited market for grain amaranth, this crop cannot be promoted as pure or sole crop alone in the initial stage. Hence, such underutilized crops like grain amaranth needs to be grown in a popular existing cropping system. In this context, present study on inter-cropping grain amaranth with other crops of regional importance was carried out to evaluate the suitability of grain amaranth as inter-crop in regular cropping system.

MATERIALS AND METHODS

The experiment on amaranth based inter-cropping system was conducted at Ranichauri centre of AICRN on potential crops during 2018 and 2019. The soil of the experimental field was silty-clay loam with a pH of 6.0. The available nitrogen in the soil was 228 kg/ha, available phosphorus 12 kg/ha and available potash 352 kg/ha. The experiment was laid out in randomized block design with three inter-crops, viz. horse gram variety 'VL Gehat1', rice bean 'Local' and French bean 'VL 63' and 3 rows ratios (1:1, 1:2 and 2:2) with 'Annapurna' amaranth as main crop replicated thrice. The furrows for sowing of all the treatments except amaranth pure were opened at 30 cm spacing, while amaranth pure was sown at 60 cm row spacing. The plant to plant spacing both for amaranth and pulses was maintained at 15 cm. A general dose of 20 kg N + 60 kg P_2O_5 per hectare was applied as basal in all the plots. Besides, an extra dose of N @20 kg per hectare was top dressed in the rows of amaranth. Necessary plant protection measures were taken to protect the crop from pests and diseases.

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RESULTS AND DISCUSSION

Main crop (amaranth)

Plant stand and growth characters

Horse gram, rice bean and french bean affected the plant stand of amaranth over its pure stand during both the years. However, row ratios did not affect the plant stand at harvest in 2018, whereas in 2019, 1:1 ratio recorded the highest number of plants per metre. In 2018, significantly highest dry matter was recorded under pure stand, followed by inter-cropping with horse gram, whereas in 2019 it was highest in inter-cropping with rice bean, followed by horse gram. Among different row ratios, 1:1 ratio gave significantly higher dry matter of amaranth.

Yield attributes

Both, the inter-crops and the row ratios affected the number of fingers per plant of amaranth in 2018 (Table 1). It was found significantly reduced with inter-crops than pure stand. Among inter-crops, horse gram recorded the highest fingers followed by french bean, whereas it was lowest with rice bean. Among row ratios, 1:2 ratio recorded the highest fingers per plant while it was lowest with 1:1 row ratio. None of the inter-crops and row ratios, however, affected the fingers of amaranth in 2019. The effect of grain weight per plant was significant in both the years. In 2018 the highest weight was recorded with pure stand, followed by inter-cropping with french bean and horse gram, whereas in 2019 inter-cropping with horse gram recorded the highest grain weight, followed by rice bean and french bean (36.38 g). Row ratio of 1:2 gave the highest grain weight.

Grain yield

Grain yield of amaranth was found significantly affected by inter-crops and row ratios and highest grain yield was recorded with pure stand (Table 2). During 2018 the inter-cropping with rice bean and french bean significantly reduced the grain yield of amaranth, while inter-cropping with horse gram proved at par with pure stand. During 2019, however, all the 03 inter-crops significantly reduced the grain yield of amaranth over its pure stand and none was found superior over others. On mean basis too, the pure stand recorded the highest grain yield, followed by inter-cropping with horse gram, rice bean and french bean. The two ratio of 1:1 gave the highest grain yield, followed by 2:2. However, there was no significant difference between the grain yields in 1:1 and 2:2 ratios in 2018. Inter-cropping with horse gram proved to be the better in 1:1 ratio, and with rice bean in 1:2 row ratio in 2018. There were no significant differences in the grain yields under different row ratios of inter-cropping with french bean. Almost similar results were recorded in 2019. Among all the combinations, the inter-cropping of amaranth with horse gram in 1:1 row ratio proved better than rest of the combinations.

Inter-crops

There were significant differences among the grain yields of different inter-crops (Table 3). Rice bean recorded the highest grain yield in 2018 and french bean in 2019. Row ratio also had a significant effect on the grain yield of inter-crops. Ratio of 1:2 recorded the second highest grain yield, the first being the pure stand. Interaction effect of row ratios and inter-crops was also significant during both the years. Rice bean recorded the highest grain when sown in 1:2 row ratio in 2018. French bean also gave highest grain yield in the same ratio. Similarly, in 2019, french bean and rice bean both yielded better when sown in 1:2 row ratio. The grain yield under pure stand of each inter-crop were, however, higher than their inter-cropping during both the years.

Amaranth equivalent

Among all the inter-cropping combinations (Table 4), amaranth + horse gram in 1:1 row ratio gave maximum amaranth equivalent. This was followed by amaranth + rice bean and amaranth + french bean, both in 1:2 row ratio in 2018 and 2019. The highest grain yield of amaranth recorded in its combination with horse gram and better compatibility of rice bean and french bean as shown by their grain yields in inter-cropping system, may be the reasons behind above results. Similarly, land-equivalent ratio was highest in amaranth + horse gram inter-cropping in

Table 1: Plant growth and yield characters of amaranth as influenced by inter-cropping with different pulses

Intercropping	*Dry matter (g)/plant at harvest*		*Fingers/plant*		*Grain weight (g)/plant*	
	2018	*2019*	*2018*	*2019*	*2018*	*2019*
Inter-crops						
Horse gram	488.89	275.59	70.71	68.15	67.22	45.25
Rice bean	460.00	276.96	55.87	63.14	47.44	41.78
French bean	463.33	201.47	67.05	60.41	73.15	36.38
Control (Pure amaranth)	540.00	222.22	74.55	64.44	73.33	26.11
CD (P=0.05)						
Inter-crop	21.52	17.23	3.13	NS	5.05	3.51
Pure crop vs inter-crops	30.43	24.37	4.43	NS	7.14	4.96
Row ratios (amaranth : pulses)						
1 : 1	503.33	282.26	56.74	63.84	62.25	36.72
1 : 2	463.33	248.55	71.37	65.59	71.48	44.03
2 : 2	455.55	221.21	64.92	62.22	54.07	42.65
CD (P=0.05)	21.52	17.23	3.13	NS	5.05	3.51

Table 2: Grain yield of amaranth (q/ha) as influenced by the interaction effect of row ratios and inter-crops.

Inter-crops	*Grain yield (q/ha)*							
	Row ratios						*Mean*	
	1 : 1		*1 : 2*		*2 : 2*			
	2018	*2019*	*2018*	*2019*	*2018*	*2019*	*2018*	*2019*
Control (Pure amaranth)							39.62	34.07
Horse gram	45.55	32.58	25.92	18.51	33.33	24.44	34.94	25.18
Rice bean	27.78	28.51	32.59	24.07	31.10	28.14	30.49	26.91
French bean	29.92	24.81	20.37	25.92	30.36	24.44	26.89	25.06
CD (P=0.05)								
Inter-cropping treatments							6.20	1.30
Inter-cropping treatments with pure stand							8.76	1.84
Interaction effects							10.73	2.26
Row ratios							6.20	1.30

Table 3: Grain yield of different inter-crops as influenced by row ratios

Inter-crops	*Row ratios*								*Pure stand*	
	1 : 1		*1 : 2*		*2 : 2*		*Mean*			
	2018	*2019*	*2018*	*2019*	*2018*	*2019*	*2018*	*2019*	*2018*	*2019*
Horse gram	2.48	5.33	4.82	4.07	2.55	2.63	4.86	4.72	9.59	6.85
Rice bean	6.47	2.92	7.22	6.67	4.38	4.55	7.69	6.02	12.66	10.59
French bean	3.52	6.25	6.44	8.66	3.71	4.20	5.04	8.30	6.48	14.00
Mean	4.16	4.84	6.16	6.47	3.54	3.57				
CD (P=0.05)										
Inter-crops							0.95	0.76		
Row ratios							1.10	0.88		
Interaction effects							1.90	1.52		

Table 4: Amaranth equivalent as influenced by inter-cropping systems.

Treatments	*Amaranth equivalent (q/ha)*		
	2018	*2019*	*Pooled*
Horse gram	39.62	34.07	36.85
Rice bean	7.67	5.48	6.57
French bean	10.13	8.47	9.30
Amaranth	6.48	14.07	10.26
Amaranth + Horse gram in 1:1 ratio	44.23	36.85	40.54
Amaranth + Rice bean in 1:1 ratio	32.97	30.86	31.91
Amaranth + French bean in 1:1 ratio	33.43	31.07	32.25
Amaranth + Horse gram in 1:2 ratio	29.75	21.77	25.76
Amaranth + Rice bean in 1:2 ratio	38.79	29.40	33.89
Amaranth + French bean in 1:2 ratio	26.85	34.58	30.72
Amaranth + Horse gram in 2:2 ratio	35.38	26.54	30.96
Amaranth + Rice bean in 2:2 ratio	34.60	31.25	26.26
Amaranth + French bean in 2:2 ratio	34.07	28.64	31.36
CD (P=0.05)	4.73	2.37	4.65

1:1 row ratio followed by amaranth + french bean and amaranth + rice bean both in 1:2 row ratio. Inter-cropping of rice bean has already bean established by Rerkasem *et al,* (1987) and Thaware *et al.* (1989) in maize and finger millet, respectively.

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