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Growth and Yield Attributes of Mustard as Influenced by Mustard – Based Vegetable Intercropping Systems

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted at Agricultural Research Station, Adilabad, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, from November, 2022 to March, 2023 to identify the best intercropping system in mustard intercropped with different root vegetable crops. The treatments include, T_1: Mustard sole crop; T_2: Radish sole crop; T_3: Beetroot sole crop; T_4: Carrot sole crop; T_5: Potato sole crop; T_6: Mustard + Radish (2:2); T_7: Mustard + Beetroot (2:2); T_8: Mustard + Carrot (2:2); T_9: Mustard + Potato (2:2); T_{10}: Mustard + Radish (3:3); T_{11}: Mustard + Beetroot (3:3) ;T_{12}: Mustard + Carrot (3:3); T_{13}: Mustard + Potato (3:3).

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Results indicated that, mustard sole crop performed significantly better in terms of growth and yield parameters. However, among the intercropping systems, mustard + radish showed higher plant height (179 and 174 cm), significantly higher plant drymatter accumulation (2478, 2456 kg/ha), number of siliqua (1689 and 1675), grain yield (972 and 950 kg/ha) and stalk yield (2267 and 2242 kg/ha) in both 3:3 and 2:2 row proportions, respectively. Moreover, all the root vegetable crops, namely radish, beetroot, carrot and potato, showed better results in terms of growth and yield parameters as sole crops compared to when grown in intercropping systems. Considering the row proportions the performance was better in 3:3 than 2:2 but not statistically significant. The study concludes that, mustard +radish in both 3:3 and 2:2 row proportions can be a better intercropping system for Telangana.

Keywords: Yield attributes; mustard based vegetable; crop; mustard.

1. INTRODUCTION

Mustard is the second most important oilseed crop, cultivated during rabi under both rainfed and irrigated conditions. Globally, India ranks second in area and third in production9.12mt, with an area of 6.85 M ha and 1331 kg ha^{-1} productivity, (Ministry of Agriculture and Farmers Welfare, 2020). In the state of Telangana area of mustard crop has been increasing over the last 4-5 years reaching 3000 ha with production of 5000 t (Telangana open data portal, 2020).

Our country has recorded the tremendous crop yields by extensive cultivation of few crops. It has reaped good yields in the short run, but in long run it is becoming unprofitable as well as unsustainable [1]. Mon culturing has depleted the soil fertility, ground water and it is one of the reasons behind soil erosion. Crop diversification holds a lot of promise in this climate change era and it stabilizes the farm income along with assurance of environmental safety [2]. There is also an impending need to develop agricultural practices that sustain yield, soil health and ecosystem in this context. Intercropping systems area pathway towards management of agroecosystems for achieving enhanced and sustained productivity. Further, the Government of Telangana is encouraging crop diversification.

There is a scope for maximizing the farmers' income by intercropping mustard with high value crops like different root vegetables crops. The success of an intercropping system will depend not only on the proper choice of the component crops but also on the spatial arrangement of plants (Ramarao and Chandranath, 2019). Intercropping mustard with root vegetable crops like carrot, radish, beetroot and potato in different spatial row arrangements is an important factor for getting a better yield advantage. Mustard and root vegetable crops differ in their morphological features viz., plant height, leaf size, root system and nutrient requirements, etc. Hence, these crops will utilize the resources efficiently which ultimately helps increase the dry matter, productivity, profitability and harvest of solar radiations.

Given the limited scope for horizontal expansion of mustard cultivation in the region, increasing mustard production can be achieved through vertical growth practices, such as intercropping with other crops.

2. MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Station, Adilabad, Telangana during *rabi,* 2022 in black soil with neutral pH (7.35), having EC of 0.19 dS/m, medium in organic carbon (0.67%) and low in available nitrogen (100.8 kg/ha), medium in phosphorus (47.4 kg/ha) and high in potassium (426 kg/ha). The experiment was laid out in randomized block design with 13 treatments namely, T1: Sole mustard; T2: Sole radish; T3: Sole beetroot; T4: Sole carrot; T5: Sole potato; T6: mustard + radish (2:2); T7: mustard + beetroot (2:2); T8: mustard + carrot (2:2); T9: mustard +potato (2:2); T10: mustard + radish (3:3); T11: mustard + beetroot (3:3); mustard + carrot (3:3); mustard +potato (3:3), replicated thrice. Plant protection measures and other packages of practices were adopted as suggested by the University.

2.1 Growth and Growth Parameters

Plant height: The plant height of five representative randomly selected and tagged plants from individual plots was measured using

a linear meter scale from the base of the plant to the apex of the growing point at 30, 60 DAS and at harvest stages. In mustard, plant height was measured at 30,60 DAS and at harvest stages. the mean value was expressed in centimetres (cm).

Dry matter production: Three plants were uprooted from the destructive sampling area of each plot at 30,60 DAS and at harvest stages and dry matter was measured. These samples were shade dried for a day and then oven dried to attain a constant weight. Final weights were recorded and expressed in (g/plant). At harvest, dry matter from net plot was measured and expressed as kg/ha**.**

2.2 Yield Attributes and Yield

Number of siliqua: One-meter square quadrant was placed in the plot and the siliqua were counted in the net plot area.

Test weight (g) (1000 seed): In mustard, treatment need samples were drawn at random and the weight of 1000 counted seeds was determined and expressed in grams.

Grain yield (kg/ha): The harvested plants from the net plot area were dried to constant weight, threshed and winnowed. The average value was expressed in kg ha^{-1}.

Stalk Yield (kg/ha): It was calculated by cutting the mustard haulms at ground level and allowing them to dry for at least a week in the respective plots, after which the dried stalks or haulms of the net plot were weighed. The average value was expressed in kg/ha.

Harvest Index (%): The Harvest index is the ratio of grain yield to the total dry matter (grain + straw yield) and is expressed as percentage. It was calculated as below

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg /}ha)}{\text{Biological yield (kg /ha)}} \times 100$$

Carrot:

1. **Root length & girth (cm):** The Length of carrot was measured by long scale and root girth were measured by Vernier callipers.
2. **Root yield (kg/ha):** The harvested plant Roots from plants separated and root yield was recorded separately on afresh weight basis per plant and computed to hectare basis. The average value was expressed in kg/ha.

Beetroot:

1. **Root length & girth (cm)**: Length of Beetroot was measured by the long scale and root girth was measured by Vernier callipers.
2. **Root yield (kg ha^{-1}):** The harvested plant Roots from plants separated and root yield was recorded separately on the fresh weight basis per plant and expressed in kg/ha.

Radish:

1. **Root length & girth (cm):** The length of carrot was measured by long scale and root girth was measured by Vernier callipers.
2. **Root yield (kg/ha):** The harvested plant roots from plants separated and root yield was recorded separately on afresh weight basis

Potato:

1. **Tuber length & girth (cm):** The Length of potato tuber is measured by long scale and tuber girth were measured by Vernier callipers.
2. **Tuber yield (kg/ha):** The harvested plant tubers from plants separated and root yield was recorded separately on the fresh weight basis per plant and expressed in kg/ha

3. RESULTS AND DISCUSSION

3.1 Growth and Growth Parameters

Plant population: The data pertaining to initial and final plant population of mustard based intercropping systems presented in Table1. Among all the treatments, the highest plant population was observed in the carrot sole crop (4,44,444) followed by the beetroot sole crop and Radish sole crop (2,22,222). In contrast, the mustard sole crop and potato sole crop both exhibited a plant population of 1,11,111 plants per hectare. While, the intercropping systems with both 2:2 and 3:3 ratios consistently recorded a plant population of 55,555 plants/ha, as they operate within a replacement series.

Plant height (cm): An overview of data pertaining to plant height (Table. 2) revealed that, sole crop of mustard had higher plant height (36,158 and 183 cm) at 30,60 DAS and at harvest compared to intercropping systems. However, mustard intercropping systems viz., mustard + radish; mustard + beetroot; mustard + carrot; mustard + potato with both 2:2 (174, 173, 171 and 173 cm) and 3:3 (179, 176,176 and 177 cm) row proportions are statistically at par with sole mustard in terms of plant height.

The rapid growth rate of mustard was observed compared to Radish, beetroot, carrot and potato. plant height of mustard was higher in replacement series of intercropping might be due to less competition. Pure stand mustard attained more height as plants had to face lesser competition than intercropping. Similar result was also reported by Awal et al. [3], Kumar et al [4], Rani et al [5] and Rahman et al [6], Chongtham et al. [7].

The Drymatter production (kg/ha): Data pertaining to drymatter production recorded at 30,60 and at harvest is presented in Table 2. Regardless of the treatments, an increment in dry matter accumulation was noticed till the harvest of the crop. The sole crop of mustard showed significantly highest in drymatter accumulation at 30,60 and at harvest with values of 534,2789 and 4366 kg ha^{-1}, respectively. Among the different intercropping systems, Mustard + Radish in 3:3 and 2: 2 recorded significantly higher dry matter accumulation (2478 and 2456 kg ha^{-1}). While the rest of the intercropping systems are statistically on par with each other. However, lowest was observed in Mustard + Potato (2:2) with a value of 2130 kg ha^{-1}.

The highest dry matter accumulation in sole crop mustard was due higher plant population per hectare at harvesting and better utilisation of limited resources effectively and in the intercropping systems, it was reduced due toa50% decrease in plant population. Similar results were found in the Lal et al. [8], Rahman et al. [6], Kaparwan et al. [9].

3.2 Yield Attributes and Yield

3.2.1 Yield attributes

Number of siliqua: Data regarding number of siliqua/m^2 of mustard as influenced by intercropping with different root vegetable crops is presented in Table 4. A pursual of data indicated that, among all the treatments, significantly highest number of siliqua/m^2, was observed in a sole crop of mustard (3080). all intercropping treatments have shown statistically no difference from each other. However, mustard + radish (3:3) has recorded higher siliqua with the value of 1505 followed by mustard + beet root (3:3) with 1496 siliqua/m^2 and the lowest was observed under mustard + beetroot (2:2) with 1483 siliqua/m^2. Similar results were observed by Akter et al. [10] and Singh *et al* [11], Roy *et al* [12].

Root length & girth (cm): Data regarding root length, and root girth was evaluated in all the intercrops (Table 3). Overall, sole crops have performed better in terms of root parameters. Root length of 16.8, 9.6, 26.3, 7.0 cm and root girth of 3.6, 6.6, 4.6, 5.7 cm was recorded in sole carrot, sole beetroot, sole radish and sole potato, respectively.

Test weight (1000 seed, g): Data regarding the test weight of mustard was shown in Table 4. Test weight did not vary significantly due to intercropping mustard with different root vegetable crops. Mustard sole crop showed the highest test weight (4.81 g) of all the treatments. Among all the intercropping systems, mustard + beetroot (3:3) recorded a higher test weight (4.78). While mustard + carrot (2:2) showed the lowest value (4.68 g). Test weight being a genetic character will not be influenced by any agronomic practices. Similar results were found by Singh and Rana [13].

3.2.2 Yield

Grain yield (kg/ha): As shown in Table 4, significantly highest mustard grain yield was observed in sole mustard crop (1556 kg ha^{-1}) compared to intercropping systems. Among, different row ratios 3:3 ratio performed well compared to 2:2. However, statistically no difference was observed between the row proportions 2:2 and 3:3.

In both 2:2 and 3:3 row proportions, mustard + radish (950 and 972 kg/ha) has recorded significantly higher yield compared to mustard + beetroot (758 and 768 kg/ha), mustard + carrot (844 and 855 kg/ha) and mustard + potato (746 and 754 kg/ha).

Root yield (kg/ha): Sole crops of carrot (20513kg/ha), radish (24212kg/ha), beetroot

Table 1. Initial and final plant population of mustard- based intercropping systems

Treatments	Initial plant population (No. /ha)		Final plant population (No. /ha)	
	Main crop	Intercrop	Main crop	intercrop
T_1 Mustard sole crop	111111	-	110981	-
T_2 Radish sole crop	222222	-	222113	-
T_3 Beetroot sole crop	222222	-	222115	-
T_4 Carrot sole crop	444444	-	444287	-
T_5 Potato sole crop	111111	-	110978	-
T_6 Mustard + Radish (2:2)	55555	111111	55478	110976
T_7 Mustard + Beetroot (2:2)	55555	111111	55467	110972
T_8 Mustard + Carrot (2:2)	55555	222222	55476	222110
T_9 Mustard + Potato (2:2)	55555	55555	55460	55473
T_{10} Mustard + Radish (3:3)	55555	111111	55448	110956
T_{11} Mustard + Beetroot (3:3)	55555	111111	55445	110965
T_{12} Mustard + Carrot (3:3)	55555	222222	55456	222113
T_{13} Mustard + Potato (3:3)	55555	55555	55458	55465

Table 2. Growth and growth parameters of mustard and carrot, beetroot, radish, and potato as influenced by mustard intercropping with different root vegetable crops

Treatments	HEIGHT						DRYMATTER					
	30 DAS		60 DAS		At harvest		30 DAS		60 DAS		At harvest	
	main crop	intercrop	main crop	Intercrop	main crop	intercrop	main crop	intercrop	main crop	intercrop	main crop	intercrop
T_1	36		158		183		533		2789		4366	
T_2	26		-		46		920		-		6972	
T_3	10		35		45		346		1036		7445	
T_4	10		37		47		864		2654		5899	
T_5	18		27		37		573		3318		6754	
T_6	34	21	152	43	174		268	450	1371		2456	3491
T_7	33	9	152	31	173	41	253	178	1362	526	1994	3745
T_8	32	8	151	33	171	42	246	434	1352	1327	2133	2958
T_9	32	15	152	24	173	33	259	282	1369	1657	1981	3397
T_{10}	35	23	155	44	179		302	470	1408		2478	3506
T_{11}	35	9	154	32	176	44	281	185	1389	534	2010	3797
T_{12}	36	9	153	35	176	45	272	447	1374	1339	2157	2997
T_{13}	35	17	155	26	177	34	291	297	1401	1671	1998	3420
SEm±	2.4	6.5	6.2				12		67		80	
CD or LSD	NS		NS		NS		NS		201		235	

Note: T_1: Mustard sole crop; T_2: Radish sole crop; T_3: Beetroot sole crop; T_4: Carrot sole crop; T_5- Potato sole crop; T_6 -Mustard + Radish (2:2); T_7 -Mustard + Beetroot (2:2); T_8- Mustard + Carrot (2:2); T_9 - Mustard + Potato (2:2); T_{10} - Mustard + Radish (3:3); T_{11} - Mustard + Beetroot (3:3) ;T_{12} - Mustard + Carrot (3:3); T_{13} - Mustard + Potato (3:3).

Table 3. Root parameters of intercrops as influenced by mustard based intercropping systems

Treatments	Root length (cm)	Root girth (cm)	Root yield (kg/ha)
T_2Radish sole crop	26.3	4.65	24212
T_3 Beetroot sole crop	9.56	6.56	20358
T_4 Carrot sole crop	16.8	3.60	20513
T_5Potato sole crop	6.96	5.74	21456
T_6 Mustard + Radish (2:2)	22.9	4.19	12506
T_7 Mustard + Beetroot (2:2)	9.24	5.45	11089
T_8 Mustard + Carrot (2:2)	14.8	3.20	10657
T_9Mustard + Potato (2:2)	6.34	5.37	10357
T_{10}Mustard + Radish (3:3)	24.8	4.27	12543
T_{11}Mustard + Beetroot (3:3)	9.39	5.97	11126
T_{12} Mustard + Carrot (3:3)	15.3	3.40	10694
T_{13} Mustard + Potato (3:3)	6.68	5.56	10764

Table 4. Yield and yield parameters of mustard as influenced by mustard intercropping with different root vegetable crops

Treatments	Test weight (g)	siliqua(m^{-2})	Grain yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)
T_1 Mustard sole crop	4.87	3080	1556	3910	28.47
T_6Mustard + Radish (2:2)	4.76	1675	950	2242	29.76
T_7 Mustard + Beetroot (2:2)	4.78	1287	758	1874	28.80
T_8 Mustard + Carrot (2:2)	4.68	1480	844	1915	30.59
T_9 Mustard + Potato (2:2)	4.70	1276	746	1860	28.63
T_{10}Mustard + Radish (3:3)	4.72	1689	972	2267	30.01
T_{11} Mustard + Beetroot (3:3)	4.73	1304	768	1885	28.95
T_{12} Mustard + Carrot (3:3)	4.74	1490	855	1924	30.77
T_{13} Mustard + Potato (3:3)	4.73	1298	754	1877	28.66
SEm±	0.2	53	33	82	1.3
CD or LSD	NS	128	98	242	NS

(25310 kg/ha) and potato22315(kg/ha) were recorded the highest root yield and tuber yield than intercropped with mustard in 2:2 and 3:3 row proportions.

Stalk yield (kg/ha): As shown in Table 4, significantly highest mustard stalk yield was observed in the sole mustard crop (3900 kg/ha) compared to intercropped mustard with row ratios of 2:2 and 3:3. Among different row ratios, 3:3 ratio performed better compared to 2:2. However, these rows were statistically on par with each other.

In both 2:2 and 3:3 row proportions, mustard + radish (2242 and 2267 kg/ha) showed significantly higher stalk yield compared to mustard + beetroot (1874 and 1885 kg/ha), mustard + carrot (1915and 1924 kg/ha) and mustard + potato (1860 and 1877 kg/ha).

Harvest Index (%): Statistically, no significant influence of mustard intercropping with different root vegetables on the harvest index of mustard was observed (Table 4). Harvest index ranged from the lowest of 28.52% to the highest of 30.67% among the given treatments.

4. CONCLUSIONS

Crop diversification holds a great promise in this climate change era and oilseeds, pulses, millets along with vegetables shall be cultivated to enhance the farmer's income. Intercropping mustard with crops like different root vegetables crops which leads to optimum utilisation of available resources like nutrients, water, light and enhances the productivity as well as income of the farmers. This study was carried out to find the best mustard based intercropping system and it is concluded that mustard +radish (3:3) has obtained highest productivity which could be recommended to the farmers of northern Telangana zone.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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