Original Research Article

Evaluation of growth and yield attributes ofmustardbasedvegetable intercropping systems.

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). Results revealed, significantly highest plant height in sole mustard with 183 cm followed by mustard +radish (3:3) with 179cm and 2:2 with 174cm. Significantly higher plant drymatter accumulation was observed in sole beetroot (7281 kg/ha) followed by carrot (5674 kg/ha)T8- Mustard + Carrot 2:2(2130), yield parameters number of siliqua and test weight, grain and stalk yield and harvest index recorded at harvest. Significantly highest no of siliqua was recorded in sole mustard (3080no m^{-2}) and lowest was recorded in mustard +carrot 2:2(1480m^{-2}) significantly highest grain and stalk yield was recorded in sole mustard (1556(kg ha^{-1}),3900(kg ha^{-1}) and lowest was recorded inmustard +carrot 2:2 :844(kg ha^{-1}),1945(kg ha^{-1}). among root vegetable crops highest root yield was recorded in sole beet root crop (25310kg ha^{-1}). and lowest was recorded in carrot + mustard 2:2 crop (10657kg ha^{-1}). significantly highest root length was recorded in Radish sole crop (26.3cm) and lowest was recorded in mustard +beetroot 2:2 (9.24) significantly highest root girth was recorded in Beetroot sole crop while lowest was found in carrot +mustard 2:2 (3.2cm). significantly highest tuber length, girth and yield was recorded in sole potato.
by considering the yields of intercropping systems mustard + radish was recorded highest it should be the best intercropping system and suggested to Telangana farmers.

1. INTRODUCTION

Mustard is the second important oilseed crop,cultivated during rabi under both rainfed andirrigated conditions. Globally, India ranks second in area and third in production with an area of 6.85 M ha and 9.12mt, 1331 kg $ha^{-1}$of production and productivity, respectively (Ministry of Agriculture and Farmers Welfare, 2020). In the state of Telangana area under mustard crop has been increasing over the last 4-5 years reaching an area of 3000 ha with production of 5000 t (Telangana open data portal, 2020).

Government of Telangana is encouraging crop diversification to reduce the cropping area of rice, especially during the rabi season because of the procurement problems associated with rice crop. There is also an impending need to develop agricultural practices that sustain yield, soil health and ecosystem in this context. Intercropping systems is a pathway towards management of agroecosystems for achieving enhanced and sustained productivity.

There is a scope for maximizing the farmers' income by intercropping mustard with high value crops like different root vegetables crops. Success of an intercropping system will depend not only on the proper choice of the component crops but also on 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 higher dry matter, higher productivity, profitability and higher harvest of solar radiations.

Given 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 on black soil, neutral in nature (pH 7.35), having EC of 0.19 dSm-1, 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 package of practices were adopted as suggested by the University.

GROWTH AND GROWTH PARAMETERS

1.Plant height

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 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 observations were taken from the representative plants and the mean value was expressed in centimetres (cm).

2.Drymatter production

Three plants were uprooted from the destructive sampling area of each plot at 30,60 DAS and at harvest stages 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-$^{-1}$). At harvest dry matter from net plot was measured and expressed as kg ha^{-1}

YIELD ATTRIBUTES AND YIELD

1.Number of siliqua m^{-2}

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

2.Test weight (g) (1000 seed)

In mustard, treatment wise seed samples were drawn at random and the weight of 1000 counted seed was determined and expressed in grams.

3. Grain yield (kg ha^{-1})

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

4.Stalk Yield (kg ha^{-1})

It was calculated by cutting the mustard haulms at ground level and allowed 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-$^{-1}$

5. Harvest Index (%)

Harvest index is the ratio of grain yield to the total dry matter (grain + straw yield) and expressed as percentage. It was calculated by the formula as given below

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Carrot:

1.Root length & girth (cm)

Length of carrot was measured by 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 fresh 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 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 fresh weight basis per plant and expressed in kg/ha.

Radish:

Root length & girth (cm)

Length of carrot was measured by long scale and root girth was measured by Vernier callipers.

1.Root yield (kg ha^{-1})

The harvested plant Roots from plants separated and root yield was recorded separately on fresh weight basis per plant and computed to hectare basis. The average value is expressed in kg/ha

Potato:

1.Tuber length & girth (cm)

Length of potato tuber is measured by long scale and tuber girth was measured by Vernier callipers.

2.Tuber yield (kg ha^{-1})

The harvested plant tubers from plants separated and root yield was recorded separately on fresh weight basis per plant and computed on hectare basis. The average value was expressed in kg ha^{-1}

3. RESULTS AND DISCUSSION

3.1 Growth and growth parameters

3.1.1 plant population (No./ha^{-1})

The data pertaining to initial and final plant population of mustard based intercropping systemsis presented in Table1. Among all the treatments,highest plant population was observed in carrot sole crop(444444) followed by beetrootsole crop and Radish sole crop (222222). 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.

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

3.1.2 plant height (cm)

An overview of data pertaining to plant height (Table. 2) revealed that, sole crop of mustard hadhigher plantheight (36,158 and 183 cm) at 30,60 DASand at harvest compared tointercropping 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.

Rapid growth rate of mustard was observed compared to Radish, beetroot, carrot and potato. Plant height of mustard was more 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 also reported by Awal et al (2006), Kumar et al (2018), Rani et al (2017) and Rahman et al (2009), Chongtham et al. (2018

3.1.3 Drymatter production(kg ha^{-1})

Data pertaining to drymatter production recorded at 30,60 and at harvest is presented in table 2. Regardless of the treatments, increment in dry matter accumulation was noticed till the harvest of the crop. 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 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}.

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 to 50% decrease in plant population. Similar results were found in Lal et al. (2017), Rahman et al. (2009).

Table 2.

Growth and growth parameters of mustard and carrot, beetroot, radish, potato as influenced by mustard intercropping with different root vegetables 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).

3.2 yield attributes and yield

3.2.1 yield attributes

Number of siliqua m^{-2}

Data regarding number of siliqua/m^2 of mustard as influenced by intercropping with different root vegetable crops is presented in the Table 4. A pursual of data indicated that, among all the treatments, significantly highest number of siliqua/m^2, was observed in sole crop of mustard (3080). While all intercropping treatments has shown statistically no difference with each other. However,mustard + radish (3:3) has recorded higher siliquawith value of 1505 followed by mustard + beet root (3:3) with 1496siliqua/m^2 and lowest was observed under mustard + beet root (2:2) with 1483 siliqua/m^2. Similar results were observed by Akter et al. (2018) and Singh *et al* (2014).

Root length & girth (cm)

Data regarding root length, 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.

Table 3. Root parameters of intercrops as influenced by mustard based inter cropping 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	3.6	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	3.2	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	3.4	10694
T_{13} Mustard + Potato (3:3)	6.68	5.56	10764

Test weight (1000 seed, g)

Data regarding the test weight of mustard shown in table 4.Test weight did not vary significantly due to intercropping mustard with different root vegetable crops. Mustard sole crop showedhighest test weight (4.81 g) of all the treatments. Amongall the intercropping systems, mustard + beetroot (3:3) recordedhigher test weight (4.78). While mustard + carrot (2:2) showedlowest value (4.68 g). Test weight being a genetic character it will not be influenced by any agronomic practices. Similar results were found by Singhand rana (2007).

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).

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

Root yield (kg/ha)

Sole crops of carrot (20513kg/ha), radish (24212kg/ha), beetroot (25310 kg/ha) and potato22315(kg/ha) were recorded highest root yield and tuber yield than intercroppedwith 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 solemustard 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 (1915 and 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 harvest index of mustard was observed (Table 4). Harvest index was ranged from lowest of 28.52% to highest of 30.67% among the given treatments.

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