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Performance of intercropping of rajmah (*Phaseolus vulgaris* L.) in *Rabi* sweet corn (*Zea mays var. Saccharata*)

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Abstract
The field investigation entitled "Performance of Intercropping of Rajmah (*Phaseolus vulgaris* L.) in *Rabi* Sweet Corn (*Zea mays var. saccharata*)" was conducted during the *Rabi* season of 2024–25 at the Zonal Agricultural Research Station, Ganeshkhind, Pune. The experiment was laid out in a Randomized Block Design (RBD) with six treatments and four replications, *viz*., T_1: Sweet corn (75 cm) + Rajmah (1:1), T_2: Sweet corn (75 cm) + Rajmah (1:2), T_3: Sweet corn (60 cm) + Rajmah (1:1), T_4: Sweet corn (Paired row 60–90–60 cm) + Rajmah (2:2), T_5: Sole Sweet corn and T_6: Sole Rajmah. Results revealed that Sole Sweet corn (T_5) recorded higher cob yield (25.07 t ha^{-1}), which was at par with Sweet corn (75 cm) + Rajmah (1:1) (T_1) (22.72 t ha^{-1}), whereas Sweet corn (60 cm) + Rajmah (1:1) (T_3) recorded higher green fodder yield (31.25 t ha^{-1}). The growth and yield attributes and cob yield fodder yield of sweet corn was found to be significant in sole sweet corn which was found at par with sweet corn (75 cm row) + rajmah (1:1). The Sweet corn equivalent yield (SCEY) was significantly higher in Sweet corn (75 cm) + Rajmah (1:2) (T_2) (30.20 t ha^{-1}), followed by Sweet corn (75 cm) + Rajmah (1:1) (T_1) (28.31 t ha^{-1}). In terms of economics, Sweet corn (75 cm) + Rajmah (1:2) (T_2) recorded higher net returns (₹ 4,46,945 ha^{-1}), followed by Sweet corn (60 cm) + Rajmah (1:1) (T_3) (₹ 4,08,702 ha^{-1}) and Sweet corn (75 cm) + Rajmah (1:1) (T_1) (₹ 4,04,277 ha^{-1}). However, the Benefit:Cost (B:C) ratio was higher in Sweet corn (75 cm) + Rajmah (1:1) (T_1) (4.44), followed by Sweet corn (75 cm) + Rajmah (1:2) (T_2) (4.36) and Sweet corn (60 cm) + Rajmah (1:1) (T_3) (4.36), indicating better profitability and efficient resource utilization.

Keywords: Intercropping, sweet corn, rajmah, sweet corn equivalent yield

Introduction
Maize (*Zea mays* L.) is a crucial cereal crop that plays a significant role in ensuring food security and supporting the socio-economic development of many developing nations worldwide. In India, it ranks as the third most important crop after rice and wheat, providing high biological and grain yields in a relatively short growing period due to its efficient photosynthetic mechanism as a C4 plant (Hatch and Slack, 1996) [8]. India's Maize crop covered in India is 11.24 million hectares, yielding a total production of 37.67 million tonnes with an average productivity of 3.35 tonnes per hectare in the 2023–24 season.
Sweet corn also known as sugar corn, is a hybrid variety of maize specifically bred to enhance its sugar content (Chaudhary *et al*., 2017) [6]. As a widely spaced plant, maize allows for the intercropping of other crops without significant economic loss, sacrificing a small portion of maize yield but increasing overall production in terms of land and time. This practice provides notable yield benefits and higher economic returns compared to monocropping due to its efficient use of growth resources (Ali *et al*., 2015) [2].
Sweet corn is a highly profitable crop that is well-suited for cultivation in peri-urban farming systems. Rather than growing it as a sole crop, it can be intercropped with other high-value crops such as vegetables or flowers. This approach helps farmers generate extra income from the same area of land and promotes more sustainable agricultural practices.
Intercropping sweet corn with rajmah during the *rabi* season has several potential advantages. First, the combination of a nitrogen-fixing legume (rajmah) with a high-demand crop (sweet

corn) could improve resource utilization, particularly nitrogen and light. Second, it could increase the total yield per unit area by providing multiple products (corn and beans) and maximizing the use of land and resources. Third, the legume-cereal combination may help in managing pests and diseases, as the diversity in plant species can reduce the chances of pest buildup (Altieri, 1999) [3].
Despite the advantages of intercropping, there is a need for region- specific studies to assess the feasibility and performance of such systems under local agro- ecological conditions. The rabi season, spanning from October to March, offers favorable conditions for cultivating various high-value crops due to cooler temperatures, low pest incidence, and availability of residual soil moisture. This season, however, also presents challenges such as water scarcity and temperature sensitivity, making strategic crop selection and management essential. Considering the above entities discussed here in, the present study is attempt to find out the suitable row ratio for sweet corn + Rajmah intercropping

Materials and Methods
The experiment was conducted at Zonal Agricultural Research Station (ZARS), Ganeshkhind, Pune during the rabi seasons of 2024-2025. According to NARP, ZARS comes under the Western Maharashtra Plain Zone. Geographically it is situated on 18 ^{0} 22` N latitude and 73$^{0}$ 51`E longitudes having an altitude of 557.74 m above mean sea level. The topography of the experiment plot was uniform. The suitable experimental site was selected for raising of sweet corn and rajmah intercrops. The field experiment was arranged in Randomized block design consist of six treatments *viz*., T_1: Sweet corn (75 cm) + Rajmah (1:1), T_2: Sweet corn (75 cm) + Rajmah (1:2), T_3: Sweet corn (60 cm) + Rajmah (1:1), T_4: Sweet corn (Paired row 60–90–60 cm) + Rajmah (2:2), T_5: Sole Sweet corn and T_6: Sole Rajmah with three replications. The soil of experimental sites was vertisol, medium black in colour and well drained, with a uniform depth of up to 90 cm. The soil of the experimental field was clay loam in texture with slightly alkaline in reaction. The soil was medium in available nitrogen, medium in available phosphorous and moderately high in available potassium as well as moderate in organic carbon content. The Gross plot size was 4.50 x 4.00 m² and net plot was as per treatments, respectively. Sole Sweet corn crop was sown at 75 cm x 20 cm and Rajmah on 30 cm X 15 cm. The varieties for Sweet Corn: *Mithas*, Rajmah:*Phule Rajmah* were used. The Rajmah for vegetables was harvested from 78 to 82 days after sowing. The recorded data were analyzed following statistical program by Panse and Sukhatme (1967). Sweet Corn equivalent yield (SEY) and BCR were calculated to ascertain the effectiveness of intercropping. Sweet Corn equivalent yield was estimated by converting the yield of intercrops to the yield of Sweet Corn on the basis of prevailing market prices of individual crops. Gross and net monetary return with B:C ratio was calculated to assess the intercropping system. Sweet Corn Equivalent Yield was calculated as per Bandyopadhyay (1984) [5]:

$$= Yield\ of\ Sweet\ Corn\ (t\ ha^{-1}) \ + [\frac{Intercrop\ Yield\ of\ Rajmah (\mathrm{t}\ ha^{-1}) \times Price\ \mathrm{of\ rajmah} \left(\frac{₹}{\mathrm{t}}\right)}{Price\ of\ Sweet\ Corn\ \left(\frac{₹}{t}\right)}]$$

Results and Discussion
Growth and yield attributes of sweet corn as influenced by intercropping with rajmah
The data pertaining to plant height, number of functional leaves, and yield attributes of sweet corn as affected by different intercropping treatments with rajmah are presented in Table 1.
Plant height of sweet corn was not significantly influenced at early stages (14, 28 and 42 DAS). At 56 DAS, a significant difference was recorded, where sole sweet corn (T_5) registered significantly higher plant height (120.90 cm) followed by Sweet corn (75 cm row) + rajmah (1:1) (T_1) (118.17 cm). At harvest, where sole sweet corn (T_5) remained significantly superior (218.45 cm), at par with (T_1) Sweet corn (75 cm row) + rajmah (1:1) (212.70 cm). The superior growth in sole cropping might be attributed to absence of inter-specific competition, which ensured better utilization of light, nutrients, and moisture. Similar findings were reported by Vidhyashree *et al*., (2019) [13] and Chaudhary (2017) [6], who observed that sole sweet corn attained higher plant height due to reduced competition
At early stages (14 and 28 DAS), intercropping systems did not exert significant influence on the number of functional leaves. However, from 42 DAS onward, significantly higher number of leaves was recorded under Sole sweet corn (T_5) with 11.15 leaves at 42 DAS, 10.45 leaves at 56 DAS, and 10.20 leaves at harvest. Among intercropped treatments, Sweet corn (75 cm row) + rajmah (1:1) (T_1) and Sweet corn (60 cm row) + rajmah (1:1) (T_3) were statistically comparable and recorded 9.00 and 9.05 leaves plant^{-1} at harvest, respectively. Reduction in leaf number in intercropping treatments could be due to partial shading by rajmah and competition for growth resources. Comparable results were obtained by Patel *et al*., (2018) [9] and Ambos and Calipusan (2017) [4], who reported fewer leaves and reduced photosynthetic area in maize or sweet-corn intercropping compared with sole cropping.
Yield attributes of sweet corn were significantly affected by intercropping systems. Significantly maximum cob length (26.48 cm), cob girth (21.06 cm) was recorded under Sole sweet corn (T_5), but it was at par with Sweet corn (75 cm row) + rajmah (1:1) (T_1) (19.46cm) and maximum grain rows cob^{-1} (16.65) were recorded under Sole sweet corn (T_5). Improved cob characters in sole sweet corn might be due to better photosynthate partitioning towards the reproductive sink under non-competitive conditions. These observations are in close agreement with Ahmad *et al*., *(*2015) [1] and Rathor (2015) [10], who reported enhanced yield components in sole or optimally spaced maize-legume systems.

Intercrop yield and sweet corn equivalent yield
The data reported in Table. 2 revealed that the maximum intercrop yield (3.59 t ha^{-1}) was obtained under Sweet corn (75 cm row) + rajmah (1:2) (T_2), followed by Sweet corn (60 cm row) + rajmah (1:1) (T_3) (2.84 t ha^{-1}) and Sweet corn (75 cm row) + rajmah (1:1) (T_1) (2.10 t ha^{-1}). In terms of system productivity, the highest SEY (30.20 t ha^{-1}) was recorded under Sweet corn (75 cm row) + rajmah (1:2) (T_2), which was statistically at par with Sweet corn (75 cm row) + rajmah (1:1) (T_1) (28.31 t ha^{-1}) and Sweet corn (60 cm row) + rajmah (1:1) (T_3) (27.57 t ha^{-1}). The higher SEY in T_2 could be attributed to the optimum proportion (1:2) of rajmah, which utilized inter-row space effectively and contributed additional yield advantage. Similar findings were reported by Ahmad *et al*., (2015) [1] and Reddy *et al*., (2009) [11], who stated that inclusion of legumes at suitable row ratios enhanced system productivity and stability in intercropping systems.

Yield and yield parameters
The data on yield attributes, yield of sweet corn under different intercropping systems are presented in Table 2. Significantly higher average cob weight both with and without husk (546.75 g and 417.10 g, respectively) was recorded under Sole sweet corn

(T_5), which was found to be at par with sweet corn (75 cm row) + rajmah (1:1) (T_1) (508.35 g and 361.05 g). Similarly, Sole sweet corn (T_5) produced the highest cob yield (25.07 t ha⁻¹), which was significantly superior to all intercropping treatments and it was found to be at par with sweet corn (75 cm row) + rajmah (1:1) (T_1)(22.72 t ha⁻¹). Significantly highest green-fodder yield (31.25 t ha⁻¹) was recorded under sweet corn (60 cm row) + rajmah (1:1) (T_3), owing to increased plant population and enhanced vegetative growth. These results are in accordance with Geren *et al.*, (2008) [7] and Tripathi *et al.*, (2009) [12], who reported that closer row spacing in maize–legume intercropping enhanced fodder yield due to increased plant density.

Economics

The maximum gross returns (₹ 580144 ha⁻¹) and net returns (₹ 446945 ha⁻¹) were obtained under Sweet corn (75 cm row) + rajmah (1:2) (T_2), which was found to be at par with Sweet corn (75 cm row) + rajmah (1:1) (T_1) (₹ 521894 ha⁻¹ and ₹ 404277 ha⁻¹) and Sweet corn (60 cm row) + rajmah (1:1) (T_3) (₹ 530194 ha⁻¹ and ₹ 408702 ha⁻¹).while highest B:C ratio (4.44) was recorded under Sweet corn (75 cm row) + rajmah (1:1) (T_1), closely followed by T_2 (4.36)

Table 1: Growth and yield attributes of sweet corn as influenced by various intercropping system

Treatments	Plant Height (cm) at					Number of functional leaves at					Length of cob (cm)	Girth of cob (cm)	Grain rows cob⁻¹
	14 DAS	28 DAS	42 DAS	56 DAS	Harvest	14 DAS	28 DAS	42 DAS	56 DAS	harvest			
T_1: Sweet corn (75 cm row) + Rajmah (1:1)	8.45	28.45	68.74	118.17	212.70	3.70	7.20	10.20	9.00	8.75	23.90	19.46	16.25
T_2: Sweet corn (75 cm row) + Rajmah (1:2)	8.40	29.85	68.42	117.47	203.80	4.00	7.45	10.10	9.00	8.05	24.15	19.26	16.20
T_3: Sweet corn (60 cm row) + Rajmah (1:1)	8.45	29.95	67.64	116.91	201.90	3.75	7.70	10.10	8.95	9.05	23.85	19.21	16.65
T_4: Sweet corn (Paired row 60-90-60 cm) +Rajmah (2:2)	10.50	25.70	67.70	116.93	200.40	3.75	7.25	10.00	8.95	8.80	23.05	18.99	16.25
T_5: Sole Sweet corn	7.75	26.30	74.86	120.90	218.45	4.00	7.15	11.15	10.45	10.20	26.48	21.06	16.65
S.Em±	0.68	1.28	1.90	0.66	3.73	0.12	0.34	0.27	0.45	0.32	0.54	0.55	0.13
CD at 5%	NS	NS	NS	2.03	11.51	NS	NS	0.83	1.39	1.00	1.66	1.70	NS

*NS= non-significant

Table 2: Yield attributes and yield of sweet corn, SEY and economics as influenced by various intercropping system

Treatment	Average weight of cob (g)		Cod yield (t ha⁻¹)	Green fodder yield (t ha⁻¹)	Intercrop yield (t ha⁻¹)	Sweet corn equivalent Yield (tha⁻¹)	Cost of cultivation (Rs.ha⁻¹)	Gross returns (Rs.ha⁻¹)	Net returns (Rs.ha⁻¹)	B: C ratio
	With husk	Without husk								
T_1:Sweet corn (75 cm row) + Rajmah (1:1)	508.35	361.05	22.72	28.87	2.10	28.31	117617	521894	404277	4.44
T_2Sweet corn (75 cm row) + Rajmah (1:2)	482.95	359.70	20.62	27.00	3.59	30.20	133200	580144	446945	4.36
T_3:Sweet corn (60 cm row) + Rajmah (1:1)	479.70	345.60	20.00	31.25	2.84	27.57	121491	530194	408702	4.36
T_4:Sweet corn (Paired row 60-90-60 cm) +Rajmah (2:2)	482.45	331.00	19.01	27.53	2.22	24.94	117617	470472	352856	4.00
T_5:Sole Sweet corn	546.75	417.10	25.07	29.32		25.07	102042	425937	323895	4.17
S.Em±	19.36	20.37	1.23	1.29		1.63		28449	28449	
C.D. at 5%	59.66	62.78	3.79	3.99		5.01		87660	87660	

Conclusion

The results of the present investigation clearly indicated that intercropping of sweet corn with rajmah in different row proportions significantly influenced the growth, yield and economic returns. among the treatments, sweet corn (75 cm row) + rajmah (1:2) (T_2) recorded significantly higher sweet corn equivalent yield (30.20 t ha⁻¹), gross returns (₹ 580144 ha⁻¹) and net returns (₹ 446945 ha⁻¹), which was found to be at par with Sweet corn (75 cm row) + rajmah (1:1) (T_1) having Sweet corn Equivalent Yield (28.31 t ha⁻¹), gross returns (₹ 521894 ha⁻¹) and net returns (₹ 404277 ha⁻¹). while B:C ratio was higher 4.4 in Sweet corn (75 cm row) + Rajmah (1:1) (T_1) hence, intercropping of sweet corn (75 cm) with rajmah in 1:1 proved to be the most productive and profitable system under the conditions of the Western Maharashtra Plain Zone.

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