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EFFECT OF MEDICINAL PLANT–FIELD CROP INTERCROPPING AND PLANTING GEOMETRY ON SOIL TEMPERATURE DYNAMICS AT DIFFERENT DEPTHS UNDER RABI CONDITIONS

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ABSTRACT

The present study was conducted during the rabi seasons of 2017–18 and 2018–19 at the medicinal plant garden of the West Bengal State Medicinal Plant Board (WSMPB), Kalyani, to evaluate the effect of medicinal plants, companion field crops, and planting arrangements on soil temperature at different depths. The experiment was laid out in a Randomized Block Design (RBD) with two replications, comprising three medicinal plants (Ashwagandha, Tulsi, and Stevia), three field crops (radish, cabbage, and mustard), and two planting arrangements (line sowing and border line sowing), resulting in 18 treatment combinations. Soil temperature was recorded at 5 cm, 10 cm, and 15 cm depths at regular intervals during the crop growth period.

The results revealed a consistent trend across all depths, where soil temperature increased from early growth stages, reached its peak around 30 days after planting (DAP), decreased gradually up to 60 DAP, and then showed a slight rise towards later stages. Among the medicinal plants, Tulsi recorded higher soil temperature, followed by Stevia, while Ashwagandha maintained comparatively lower values due to better canopy cover and shading effect. In case of companion crops, cabbage and mustard exhibited higher soil temperatures, whereas radish recorded lower values, likely due to its faster growth and greater ground coverage. Soil temperature fluctuations were more pronounced at 5 cm depth compared to 10 cm and 15 cm, indicating greater sensitivity of surface layers to atmospheric conditions.

Planting arrangement significantly influenced soil temperature, with border line sowing recording higher values than line sowing due to increased exposure of soil to solar radiation. Interaction effects among treatments indicated that soil temperature is governed by a combination of crop type, canopy structure, and planting geometry. Intercropping systems were found to be more effective in maintaining soil temperature within an optimum range (18–22°C), particularly around 60 DAP, which is crucial for root growth and crop development.

Overall, the study demonstrates that appropriate crop combinations and planting arrangements can effectively regulate soil thermal regimes, improve soil microclimate, and enhance crop performance under rabi conditions.

Keywords : Soil temperature dynamics, intercropping systems, Medicinal plants, Planting geometry, Soil microclimate regulation.

Introduction

Soil temperature is a key factor influencing crop growth, root activity, and soil microclimate. Several researchers have reported that intercropping systems significantly affect soil temperature through canopy shading and modification of radiation reaching the soil surface. Ekka *et al*. (2017) observed that differences in soil temperature under tree–mustard systems were mainly due to reduced solar radiation and the presence of surface residues. Similarly, Ghanbari *et al*. (2010) reported that soil temperature was highest under sole maize and lowest under sole cowpea, indicating the role of crop canopy in regulating soil heat.

Olasantan *et al*. (1996) found that intercropping maize with cassava reduced the radiant energy reaching the soil surface, resulting in lower maximum soil temperatures compared to sole cropping. Clinch *et al*. (2009) also reported that soil temperature was lower under agroforestry systems due to reduced light intensity, suggesting that moderate shading helps in stabilizing soil temperature under varying weather conditions. Likewise, Eskandari and Ghanbari (2009) observed significantly lower soil temperatures in intercrop treatments compared to sole crops at different growth stages.

Salau *et al*. (2015) reported that cassava–pumpkin intercropping reduced soil temperature while improving soil moisture compared to other crop combinations. Nyawade *et al*. (2019) found that potato–legume intercropping significantly lowered soil temperature in the root zone and improved soil water content, leading to higher crop productivity. Earlier, Ikeorgu and Ezumah (1991) also observed that soil temperature under sole cassava was reduced when intercropped with maize and other crops.

In addition, Oraon *et al*. (2005) highlighted that intercropping systems improve resource use efficiency, resulting in higher productivity compared to sole cropping. Overall, these studies indicate that intercropping plays an important role in reducing and stabilizing soil temperature by modifying canopy cover and radiation interception, thereby creating a favorable microclimate for better crop growth and soil moisture conservation.

Materials and Methods

The present study was carried out during the rabi seasons of 2017–18 and 2018–19 at the medicinal plant garden of the West Bengal State Medicinal Plant Board (WSMPB), Kalyani. The experimental site is situated near the Tropic of Cancer at an elevation of 7.8 m above mean sea level, located at 24°11′ N latitude and 88°48′ E longitude. The soil of the area falls under the Gangetic alluvial zone and is characterized by sandy loam texture with medium fertility status. The field was maintained under organic conditions and was uniform, level, and well-drained, providing suitable conditions for the cultivation of medicinal plants.

The region experiences a subtropical humid climate with an average annual rainfall of about 1470 mm, the majority of which is received during the southwest monsoon season from June to September. The climate is broadly divided into three seasons: summer, monsoon, and winter. Summer temperatures generally reach around 30°C, while winter temperatures range between 10°C and 15°C. During the crop growth period, the total rainfall received was 90 mm in 2017–18 and 130 mm in 2018–19. The mean weekly maximum temperature ranged from 18.5°C to 31.7°C during the first year and from 23.1°C to 30.6°C during the second year. Similarly, the mean weekly minimum temperature varied from 9.7°C to 20.9°C in 2017–18 and from 6.5°C to 15.2°C in 2018–19. Other weather parameters such as relative humidity, sunshine hours, and evaporation also showed variations and played an important role in influencing crop growth and soil microclimate, soil temperature at different depths was recorded using a digital soil thermometer at 15-day intervals from sowing to crop maturity

The experiment was conducted using a Randomized Block Design (RBD) with two replications. It comprised three medicinal plants, namely Ashwagandha, Tulsi, and Stevia, along with three companion field crops radish (JULI), cabbage (CHAKRA), and mustard (B-9). Two planting arrangements were followed: line sowing in a 2:1 ratio (two rows of field crops alternated with one row of medicinal plants) and border line sowing, in which medicinal plants were surrounded by two rows of field crops. In total, 18 treatment combinations were tested, resulting in 36 experimental plots. Each plot measured 4 m × 2 m with a spacing of 40 cm × 30 cm, and all observations were recorded at 11:00 AM.

Result and Discussion

As described earlier in the Materials and Methods, soil temperature at different depths was recorded using a digital soil thermometer at 15-day intervals from sowing to crop maturity. At 5 cm depth, soil temperature was measured regularly during the rabi seasons to assess the influence of medicinal plants, companion field crops, and planting arrangements on the soil thermal regime. The observations, as presented in Table 1, revealed a clear and consistent trend, where soil temperature increased from early growth stages, reached its maximum around 30 days after planting (DAP), declined gradually up to 60 DAP, and then showed a slight increase towards 75 and 90 DAP. Being closer to the surface, the 5 cm depth exhibited greater temperature fluctuations compared to deeper layers due to direct exposure to solar radiation and atmospheric conditions.

During the study period, the minimum soil temperature at 5 cm depth was recorded at 60 DAP, with values of 15.16°C, 14.40°C, and 13.62°C under Ashwagandha, Tulsi, and Stevia, respectively. In contrast, the maximum soil temperature was observed at 30 DAP, with values of 20.79°C under Ashwagandha, 24.55°C under Tulsi, and 23.07°C under Stevia (Table 1). Among the medicinal plants, Tulsi consistently recorded higher soil temperature, followed by Stevia, while Ashwagandha maintained comparatively lower values, likely due to better canopy cover and shading effect that reduced heat penetration into the soil.

In the case of companion field crops, a similar pattern was observed. The maximum soil temperature occurred at 30 DAP, with values of 20.77°C for radish, 21.44°C for cabbage, and 22.71°C for mustard, while the minimum temperature was recorded at 60 DAP, ranging from 14.47°C to 15.12°C (Table 1). Mustard recorded the highest soil temperature, followed by cabbage, whereas radish maintained lower values, which can be attributed to its faster growth and better ground coverage that reduces soil heat load.

Planting arrangement had a pronounced effect on soil temperature at 5 cm depth. Border line sowing consistently recorded higher soil temperature compared to line sowing due to greater exposure of soil to solar radiation, while line sowing maintained relatively lower values because of more uniform canopy cover. However, at 45 DAP and 90 DAP, both planting arrangements maintained comparatively optimum soil temperature conditions, indicating the stabilizing effect of crop canopy during later growth stages.

The interaction effects among medicinal plants, field crops, and planting arrangements showed varying levels of significance. Interactions such as A × M and M × F were significant at certain stages, while others were non-significant, indicating that soil temperature variation is governed by a combination of crop type, canopy structure, and planting geometry. Overall, soil temperature at 5 cm depth was highly sensitive to crop type and management practices. Intercropping systems were effective in maintaining soil temperature within a moderate range, particularly around 60 DAP when canopy cover was maximum, thereby creating a favorable soil microclimate for better crop growth and moisture conservation under rabi conditions (Table 1).

Soil temperature at 10 cm depth during the rabi seasons of 2017–18 and 2018–19 was recorded at regular intervals from 30 to 90 days after planting to study the influence of medicinal plants, companion field crops, and planting arrangements on soil thermal regime. The observations, as presented in Table 2, revealed a consistent pattern in which soil temperature increased up to 30 DAP, reached its peak, and then gradually declined to a minimum at 60 DAP, followed by a slight rise towards 75 and 90 DAP. During 2017–18, the minimum soil temperature was recorded at 60 DAP (around 16.79°C under Ashwagandha), while the maximum reached about 24.36°C at 30 DAP. A similar trend was maintained during 2018–19 with only minor variations, confirming the stability of seasonal soil temperature dynamics.

Among the medicinal crops, Tulsi generally recorded higher soil temperature, followed by Stevia, whereas Ashwagandha maintained comparatively lower values throughout the crop growth period. For example, Tulsi showed temperatures around 25°C at 30 DAP and about 17.3°C at 60 DAP, while Stevia exhibited a similar trend with slightly higher peak values and marginally reduced temperatures in the second season (Table 2). The lower soil temperature under Ashwagandha may be attributed to better canopy cover and shading effect, which reduces the amount of solar radiation reaching the soil surface.

In the case of companion field crops, a similar trend was observed where the lowest soil temperature occurred at 60 DAP and the highest at 30 DAP. During 2018–19, the minimum soil temperature was about 15.79°C under radish, 17.36°C under cabbage, and 18.03°C under mustard. The maximum values at 30 DAP were comparatively higher, with cabbage and mustard recording higher soil temperature than radish (Table 2). This variation is mainly due to differences in crop growth rate and canopy development, where radish provides quicker ground cover and reduces soil heating, while cabbage and mustard allow more solar radiation to penetrate during early stages.

Planting arrangement also had a noticeable effect on soil temperature. Border line sowing generally maintained relatively higher soil temperature compared to line sowing due to greater exposure of soil surface to sunlight. However, at 60 DAP, border line sowing provided a more favorable and moderate soil temperature (around 17.21°C), indicating its role in maintaining an optimum soil thermal environment during the critical growth stage.

Overall, the results indicate that soil temperature at 10 cm depth is significantly influenced by crop type, growth stage, and planting geometry. Intercropping systems were more effective in regulating soil temperature within an optimum range, particularly around 60 DAP when canopy development is maximum. These findings highlight the importance of crop combinations and planting methods in modifying soil microclimate, which is essential for better root development, moisture conservation, and efficient crop growth under rabi conditions (Table 2).

As outlined in the Materials and Methods, soil temperature at various depths was measured using a digital soil thermometer at 15-day intervals from sowing until crop maturity. At 15 cm depth, observations were recorded during the rabi seasons to evaluate the effects of medicinal plants, companion field crops, and planting arrangements on the soil thermal regime. The data presented in Table 3 indicated a trend similar to other depths, where soil temperature increased during the early growth stages, reached a peak around 30 days after planting (DAP), then gradually declined up to 60 DAP, followed by a slight increase towards the later stages. Compared to the 5 cm and 10 cm layers, temperature variation at 15 cm depth was relatively less due to limited direct exposure to atmospheric conditions.

The lowest soil temperature at 15 cm depth was recorded at 60 DAP, with values of approximately 15.85°C under Ashwagandha, 16.12°C under Tulsi, and 15.74°C under Stevia. In contrast, the highest soil temperature was observed at 30 DAP, with values of about 23.36°C, 23.38°C, and 23.70°C under Ashwagandha, Tulsi, and Stevia, respectively (Table 3). Among the medicinal crops, Tulsi generally maintained higher soil temperature, followed by Stevia, whereas Ashwagandha recorded lower values, which may be attributed to better canopy cover and enhanced shading that reduced heat penetration into deeper soil layers.

A similar pattern was observed among the companion field crops, where the maximum soil temperature occurred at 30 DAP, with values of approximately 22.40°C for radish, 23.71°C for cabbage, and 24.23°C for mustard. The minimum temperature was recorded at 60 DAP, with values around 15.85°C, 16.12°C, and 15.74°C for radish, cabbage, and mustard, respectively (Table 3). Mustard and cabbage exhibited relatively higher soil temperatures compared to radish, likely due to differences in canopy development and ground coverage.

Planting arrangement also affected soil temperature at this depth, with border line sowing generally recording higher temperatures than line sowing due to increased exposure of the soil surface to solar radiation. However, at 60 DAP, soil temperature under both planting arrangements remained within a moderate and favorable range, indicating the stabilizing influence of crop canopy during the peak growth period.

The interaction effects among medicinal plants, field crops, and planting arrangements showed varying degrees of significance, suggesting that soil temperature at 15 cm depth is controlled by the combined effect of crop type, canopy structure, and planting geometry. Overall, soil temperature at this depth was comparatively stable with less fluctuation than upper layers. Intercropping systems proved effective in maintaining soil temperature within an optimum range, particularly around 60 DAP, thereby supporting better root activity, moisture conservation, and overall crop performance under rabi conditions (Table 3).

Conclusions

Based on the results of the rabi seasons 2017–18 and 2018–19, it can be concluded that soil temperature at 5, 10, and 15 cm depths was significantly affected by medicinal plants, companion field crops, and planting arrangements. A similar trend was observed at all depths, where soil temperature increased during early growth stages, reached its peak around 30 days after planting (DAP), decreased up to 60 DAP, and then slightly increased towards later stages. The lowest soil temperature at all depths was recorded at 60 DAP due to maximum canopy cover, which reduced the amount of solar radiation reaching the soil surface.

Soil temperature fluctuations were highest at 5 cm depth and decreased with increasing depth, showing that deeper layers are more stable. Among medicinal plants, Tulsi recorded higher soil temperature, followed by Stevia, while Ashwagandha showed lower values due to better shading. Among companion crops, cabbage and mustard had higher soil temperatures, whereas radish maintained lower temperatures because of its faster ground coverage.

Planting arrangement also influenced soil temperature, with border line sowing recording higher values than line sowing due to greater exposure to sunlight. However, at 60 DAP, both arrangements maintained soil temperature within an optimum range, indicating the regulating effect of crop canopy.

Overall, intercropping systems were more effective than sole cropping in maintaining soil temperature within a favorable range (18–22°C). The study suggests that proper crop combinations and planting methods can help regulate soil temperature, improve soil microclimate, conserve moisture, and enhance crop performance under rabi conditions.

Table 1 : Measurement of soil temp at 5cm depth of selected medicinal plants as influenced by different types, field crops and planting arrangements during *rabi* season of 2017-18 and 2018-19

		Soil temperature at 5 cm depth						Soil temperature at 5 cm depth					
Treatment		**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**
M1(Ashwagandha)		22.24	26.79	20.94	18.16	21.78	24.21	20.22	20.79	19.94	15.16	19.78	19.21
M2(Tulsi)		22.18	27.55	21.83	18.48	21.27	24.20	20.18	24.55	18.83	14.48	18.27	22.20
M3(Stevia)		22.47	27.07	21.40	18.62	21.54	23.79	20.47	23.07	21.40	13.62	17.54	19.79
SEm(±)		**0.05**	**0.23**	**0.14**	**0.18**	**0.22**	**0.01**	**0.05**	**0.23**	**0.14**	**0.18**	**0.22**	**0.01**
CD at 5%		**0.15**	**NS**	**0.41**	**NS**	**NS**	**0.03**	**0.15**	**NS**	**0.41**	**NS**	**NS**	**0.03**
*F1(Radish)		21.75	25.44	20.70	17.12	20.16	23.63	19.75	20.44	19.70	15.12	18.16	19.63
*F2(Cabbage)		22.28	27.26	21.25	18.47	22.05	23.84	18.28	21.26	18.25	14.47	16.05	20.84
*F3(Mustard)		22.86	28.71	22.21	19.66	22.37	24.73	17.86	22.71	17.21	14.66	15.37	21.73
SEm(±)		**0.05**	**0.23**	**0.14**	**0.18**	**0.22**	**0.01**	**0.05**	**0.23**	**0.14**	**0.18**	**0.22**	**0.01**
CD at 5%		**0.15**	**0.68**	**0.41**	**0.53**	**0.65**	**0.03**	**0.15**	**0.68**	**0.41**	**0.53**	**0.65**	**0.03**
A1 (Line sowing)		21.10	25.44	20.46	18.30	20.86	23.77	26.49	29.83	20.31	14.54	19.19	20.37
A2 (Border line sowing)		23.49	28.83	22.31	18.54	22.19	24.37	23.10	22.44	18.46	16.30	18.86	20.77
SEm(±)		**0.04**	**0.19**	**0.11**	**0.14**	**0.18**	**0.01**	**0.04**	**0.19**	**0.11**	**0.14**	**0.18**	**0.01**
CD		**0.12**	**0.56**	**0.33**	**NS**	**0.53**	**0.02**	**0.12**	**0.56**	**0.33**	**NS**	**0.53**	**0.02**
A×M	**Sem(±)**	**0.09**	**0.40**	**0.24**	**0.31**	**0.38**	**0.02**	**0.09**	**0.40**	**0.24**	**0.31**	**0.38**	**0.02**
	CD	**0.25**	**1.18**	**0.71**	**NS**	**1.13**	**0.05**	**0.25**	**1.18**	**0.71**	**NS**	**1.13**	**0.05**
A×F	**Sem(±)**	**0.09**	**0.40**	**0.24**	**0.31**	**0.38**	**0.02**	**0.09**	**0.40**	**0.24**	**0.31**	**0.38**	**0.02**
	CD	**0.25**	**1.18**	**NS**	**NS**	**1.13**	**0.05**	**0.25**	**1.18**	**NS**	**NS**	**1.13**	**0.05**
M×F	**Sem(±)**	**0.09**	**0.40**	**0.24**	**0.31**	**0.38**	**0.02**	**0.09**	**0.40**	**0.24**	**0.31**	**0.38**	**0.02**
	CD	**0.25**	**1.18**	**0.71**	**0.91**	**NS**	**0.05**	**0.25**	**1.18**	**0.71**	**0.91**	**NS**	**0.05**
A×M×F	**Sem(±)**	**0.12**	**0.56**	**0.33**	**0.43**	**0.54**	**0.02**	**0.12**	**0.56**	**0.33**	**0.43**	**0.54**	**0.02**
	CD	**0.36**	**1.67**	**1.00**	**1.29**	**1.60**	**0.07**	**0.36**	**1.67**	**1.00**	**1.29**	**1.60**	**0.07**

*Field crops in association with medicinal plants

Table 2 : Measurement of soil temp at 10cm depth of selected medicinal plants as influenced by different types, field crops and planting arrangements during *rabi* season of **2017-18 and 2018-19**

		Soil temperature 10 cm during 2017-18						Soil temperature 10 cm during 2018-19					
Treatment		**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**
M1(Ashwagandha)		20.55	24.36	19.64	16.79	19.06	22.26	20.91	24.29	20.13	16.79	19.68	22.26
M2(Tulsi)		20.50	25.43	19.98	17.38	18.93	22.38	20.97	25.62	20.40	17.38	19.51	22.38
M3(Stevia)		20.72	25.05	19.72	16.93	19.64	22.14	21.15	25.19	20.23	16.93	20.32	22.14
SEm(±)		**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.14**	**0.22**	**0.01**	**0.25**	**0.01**
CD at 5%		**0.03**	**0.02**	**0.04**	**0.03**	**0.03**	**0.03**	**0.02**	**0.41**	**NS**	**0.03**	**NS**	**0.03**
*F1(Radish)		19.94	23.64	19.25	15.84	18.97	21.98	20.29	23.57	19.44	15.84	20.03	21.98
*F2(Cabbage)		20.61	25.41	19.53	17.23	18.08	22.09	21.09	25.60	19.97	17.23	18.78	22.09
*F3(Mustard)		21.22	25.79	20.57	18.03	20.58	22.70	21.64	25.93	21.35	18.03	20.71	22.70
SEm(±)		**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.14**	**0.22**	**0.01**	**0.25**	**0.01**
CD at 5%		**0.03**	**0.02**	**0.04**	**0.03**	**0.03**	**0.03**	**0.02**	**0.41**	**0.64**	**0.03**	**0.75**	**0.03**
A1 (Line sowing)		19.66	23.52	19.12	16.86	18.42	22.07	19.86	23.65	19.49	16.86	19.12	22.07
A2 (Border line sowing)		21.52	26.37	20.44	17.21	20.00	22.45	22.16	26.42	21.02	17.21	20.55	22.45
Sem(±)		**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.11**	**0.18**	**0.01**	**0.21**	**0.01**
CD at 5%		**0.03**	**0.02**	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.34**	**0.53**	**0.02**	**0.61**	**0.03**
A×M	**SEm(±)**	**0.02**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.24**	**0.37**	**0.02**	**0.44**	**0.02**
	CD at 5%	**0.05**	**0.04**	**0.06**	**0.05**	**0.05**	**0.06**	**0.04**	**0.71**	**NS**	**0.05**	**NS**	**0.06**
A×F	**SEm(±)**	**0.02**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.24**	**0.37**	**0.02**	**0.44**	**0.02**
	CD at 5%	**0.05**	**0.04**	**NS**	**0.05**	**0.05**	**0.06**	**0.04**	**0.71**	**1.12**	**0.05**	**NS**	**0.06**
M×F	**SEm(±)**	**0.02**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.24**	**0.37**	**0.02**	**0.44**	**0.02**
	CD at 5%	**0.05**	**0.04**	**0.06**	**0.05**	**0.05**	**0.06**	**0.04**	**0.71**	**NS**	**0.05**	**1.30**	**0.06**
A×M×F	**SEm(±)**	**0.03**	**0.02**	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.34**	**0.53**	**0.02**	**0.62**	**0.03**
	CD at 5%	**0.08**	**0.06**	**0.09**	**0.07**	**0.07**	**0.09**	**0.06**	**NS**	**NS**	**0.07**	**NS**	**0.09**

*Field crops in association with medicinal plants

Table 3 : Measurement of soil temp at 15 cm depth of selected medicinal plants as influenced by different types, field crops and planting arrangements during *rabi* season of 2017-18 and 2018-19.

	Soil temperature at 15 cm depth during 2017-18						**Soil temperature at 15 cm depth during 2018-19**					
Treatment	**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**
M1(Ashwagandha)	20.55	23.36	19.33	15.85	17.86	20.48	20.55	23.38	19.33	15.85	17.86	20.48
M2(Tulsi)	20.50	23.38	19.33	16.12	17.75	20.77	20.50	23.40	19.33	16.12	17.75	20.77
M3(Stevia)	20.72	23.70	19.38	15.74	18.07	20.43	20.72	23.63	19.38	15.74	18.07	20.43
SEm(±)	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.11**	**0.01**	**0.01**	**0.01**	**0.01**
CD at 5%	**0.03**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**NS**	**0.03**	**0.03**	**0.03**	**0.03**
*F1(Radish)	19.94	22.49	18.70	14.98	18.13	20.33	19.94	22.59	18.70	14.98	18.13	20.33
*F2(Cabbage)	20.61	23.71	19.25	16.01	16.54	20.28	20.61	23.56	19.25	16.01	16.54	20.28
*F3(Mustard)	21.22	24.23	20.08	16.72	19.01	21.06	21.22	24.27	20.08	16.72	19.01	21.06
SEm(±)	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.11**	**0.01**	**0.01**	**0.01**	**0.01**
CD at 5%	**0.03**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.33**	**0.03**	**0.03**	**0.03**	**0.03**
A1 (Line sowing)	19.66	22.27	18.66	15.55	16.93	20.48	19.66	22.21	18.66	15.55	16.93	20.48
A2 (Border line sowing)	21.52	24.68	20.03	16.26	18.86	20.63	21.52	24.73	20.03	16.26	18.86	20.63
SEm(±)	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.09**	**0.01**	**0.01**	**0.01**	**0.01**
CD at 5%	**0.03**	**0.03**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.27**	**0.02**	**0.02**	**0.03**	**0.03**
A×M SEm(±)	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.19**	**0.02**	**0.02**	**0.02**	**0.02**
CD at 5%	**0.05**	**0.06**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.58**	**0.05**	**0.05**	**0.05**	**0.05**
A×F SEm(±)	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.19**	**0.02**	**0.02**	**0.02**	**0.02**
CD at 5%	**0.05**	**0.06**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**NS**	**0.05**	**0.05**	**0.05**	**0.05**
M×F SEm(±)	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.19**	**0.02**	**0.02**	**0.02**	**0.02**
CD at 5%	**0.05**	**0.06**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.58**	**0.05**	**0.05**	**0.05**	**0.05**
A×M×F SEm(±)	**0.03**	**0.03**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.27**	**0.02**	**0.02**	**0.03**	**0.03**
CD at 5%	**0.08**	**NS**	**0.07**	**0.07**	**0.08**	**NS**	**0.08**	**NS**	**0.07**	**0.07**	**0.08**	**NS**

*Field crops in association with medicinal plants.

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