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Soil moisture content and fertility status of soil through intercropping of medicinal crops in guava orchard of Northern India

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ABSTRACT

A field experiment was conducted at the well-established nine year old guava orchard of Horticultural Research Farm, Khalsa College, Amritsar during 2019-20 and 2020-21, to investigate the effect of medicinal plants on soil physico-chemical properties of guava orchard at two depths (i.e. 0-15 and 15-30cm). The comprising of seven treatments such as T1: Guava+Aloe vera, T2: Guava+Brahmi, T3: Guava+Lemongrass, T4: Guava+Mentha, T5: Guava+Stevia, T6: Guava+Turmeric and T7: Guava sole. The experimental field soil was sandy loam, slightly alkaline soil reaction with medium range of organic carbon (OC) and available nitrogen (N), phosphorus (P) and potassium (K). The results indicate that soil pH and EC were non-significantly affected under different guava based intercropping system. Higher soil moisture content was recorded with brahmi and mentha intercrops in orchard. The sole treatments (T7) had higher bulk density values among all other treatments. Soil porosity had significantly higher while the intercropping of brahmi (50.06%) under fruit based system. The organic carbon content of orchard soil found significant improved from both depths 0-15 and 15-30cm due to intercropping as comparison to guava sole. The availability of macronutrients (N, P and K) were enhanced by all the intercropping system of guava orchard. Significantly maximum (222.57 and 209.86 kg ha^{-1}) available N was recorded in T4 (Guava+Mentha) and the lowest (208.41 and 194.60 kg ha^{-1}) available nitrogen was found in T7 (Guava sole) treatment within soil depths of 0-15 and 15-30 cm. Similarly, the available P and K status of soil was recorded highest when medicinal crops were grown under guava based intercropping as compared to guava sole.

Key words: *Medicinal plants, Fertility status, Intercropping, Guava orchard*

Introduction

Realizing the beneficial health effect of medicinal plants, their demand has increased all over the world. Thus, growing of medicinal plants in the fruit orchard would be the option to meet the demand of pharmaceutical industry as well as to conserve the different species without any additional land (Nandi and Ghosh, 2016). However, due to extensively grown higher valued crops, the area under medicinal crops cannot be increased; therefore orchard groundcover practices can be diversified to promote these crops. Guava (*Psidium guajava* L.) is one of the most important and delicious tropical fruit crop of the world as well as in India (Sau *et al.*, 2016). In India, it is grown in an area of 308 thousand hectares with the production of 4582 thousand MT (Anonymous 2021). It is generally planted at 6 x 6 m spacing, which provide an ample scope for cultivation of short duration crops. The vacant space in fruit crops should be judiciously used for growing of medicinal herbs such as lemongrass, mint, brahmi, turmeric etc. as cover crops which not only sustain the orchardist during the non-fruiting months of the main crop but also add to the fertility of the soil by enhancing the soil health.

The conventional tillage or use of weedicides is a common practices to control weeds in an orchard but it is not considered a sustainable approach. Better and scientifically grown ground cover crops may have been proved to be valuable for the orchard environment which includes increased beneficial organism populations, improved soil organic matter and resilience (Lemessa and Wakjira, 2015) and reduced soil sickness. Intercropping is one of the techniques of land utilization for greater stability in production as well as help the farmers in maintaining the soil fertility level (Bhattanagar *et al.*, 2007). The combination of medicinal plants provides another chance to study diversification of existing land use systems for beneficial environmental impacts and higher profits as related to sole cropping systems. Hence, the experiment was carried out to evaluate the reliable intercropping system in the guava orchard to upgrade the soil fertility status.

Materials and Methods

The field experiment was conducted during 2019-20 and 2020-21 at the Horticulture Research Farm, Khalsa College Amritsar is situated at 31° 38' N latitude 74° 49' E longitude and at an altitude of 236 m above mean sea level. It is characterized by subtropical climate with average maximum temperature of about 45-48°C. During the whole period of research the rainfall range was from 44.0 mm - 3.0 mm. The highest maximum temperature of 36.3 °C was recorded in the month of April and the lowest 18.3 °C in January. The temperature started decreasing from the month of October till January and again it was in increasing range from February to April. The highest minimum temperature of 18.7 °C was recorded in the month of October which then started to decrease in the next months. During winter the minimum temperature ranged from 6.6 to 8.7 °C in the months of December to February which again showed an increasing range in the months of March and April.

The nine year old plantation of guava at 6 x 6 m spacing, intercropped with six herbal medicinal plants crops. The comprising seven treatments such as T_1: Guava+Aloe vera, T_2: Guava+Brahmi, T_3: Guava+Lemongrass, T_4: Guava+Mentha, T_5: Guava+Stevia, T_6: Guava+Turmeric and T_7: Guava sole. The recommended agronomic practices were adopted separately for the guava and intercrops. FYM was applied @ 10 t ha^{-1} to all the plots uniformly except control and was incorporated into the soil at the time of land preparation. No serious pest and disease was noticed in the experimental fruit crops and intercrops. The statistically experimental design was randomized block design (RBD) with 7 plots and 3 replicates.

Soil samples will be collected randomly from each block of the medicinal crops in guava orchard. Sampling will be done at the end of the experiment and before the sowing of medicinal crops. Soil samples were collected having two depths from 0-15 and 15-30 cm in each cropping system. Soil moisture content (SMC) was estimated at 0-15cm soil depth by gravimetrically using samples from all treatments and monthly data from transplanting of intercrop till final harvest. Soil samples were air dried and sieved in the soil lab for the physico-chemical analysis. The physical properties of soil i.e. bulk density and porosity of soil samples were determined by using core sampler method (Prihar and Hundal, 1971), with the help of metallic cores having inner diameter of 6.8 and 7.5 cm length.

Soil porosity was determined by using formula:

Porosity (%) = (1-bulk density/2.65) x 100

The soil had sandy loam in texture, characterized by pH of 7.76, electrical conductivity (EC) of 0.42 dS m^{-1} (1:2 soil water suspension method) with organic carbon (OC) 0.44 per cent (Walkey and Black method). The initial content of soil available nitrogen (202.37 kg ha^{-1}), phosphorus (21.25 kg ha^{-1}) and potassium (291.56 kg ha^{-1}) was estimated by alkaline permanganate method, Olsen's method and neutral ammonium acetate method, respectively. The data was analyzed by online OPSTAT software and LSD was calculated at 5 per cent level of significance (Snedecor and Cochran, 1967).

Results and Discussion

The data on soil moisture content (%) at monthly interval at 0-15 cm soil depth in various intercropping treatments in guava orchard are presented in Fig. 1. Higher moisture content of soil was recorded throughout the growing period in all the intercropping systems when compared to control. The brahmi and mentha intercrops are more beneficial resulted in highest soil moisture content compared to other treatments and control. The soil moisture per cent under different intercropping systems were in the order of brahmi > mentha > turmeric > aloe vera > lemongrass > stevia > orchard sole (control). This may be due to lower row spacing and larger foliage coverage and reduce the evaporation losses from vacant interspace of orchard (Khokhar and Singh, 2015). Moreover, incorporation of crop biomass into the soil, which helped conserve the soil moisture due to structural improvement (Kumar and Pandey, 2004).

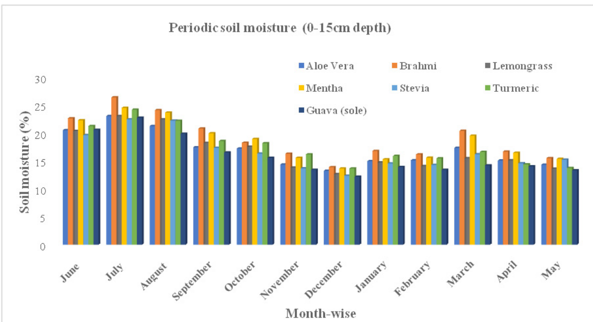

Fig. 1. Periodic soil moisture content from surface of soil as affected by various intercropping treatments in guava orchard during 2020-2021

The data about bulk density has been presented in Table 1 which indicates that regarding different intercropping systems under guava-based intercropping systems, there was a significant variation in the values of bulk density of soil at both depths. The lowest values of bulk density were recorded in brahmi intercropped plots (T2) which was at par with mentha (T4), lemongrass (T3), and turmeric (T6) intercropped treatments. The sole treatments (T7) had higher bulk density values among all other treatments. The reduced values of bulk density by intercropping of medicinal crops under fruit orchard may be due to the addition of litter leaf of cover crops and root biomass promoting soil aggregation and improving structure which leads to increased pore space and ultimately decrease in bulk density (Singh *et al.* 2012). Swain and Patro (2007) also reported a decrease in the bulk density of soil studying the effects of different intercropping in mango orchards.

The value of porosity varied from 47.67 to 50.06 per cent and 46.42 to 48.82 per cent from both depths 0-15 and 15-30 cm, respectively. While the intercropping of brahmi (50.06%) under fruit based system had significantly higher porosity which was very close to mentha and turmeric inter cropped blocks and lowest value found in T_7 (47.67%) from the surface of soil. The high porosity under guava based cropping might be due to the addition of more organic matter content on weight basis, better aggregation and changing pore size distribution of the soil. Saha *et al.* (2010) and Fen *et al* (2006) reported increase in soil porosity after intercropping due to increased root biomass.

Soil parameters in regards to soil pH and EC (Table 2) were slightly improved due to growing of medicinal plants in the interspace of the guava orchard. However, the intercropping and soil depth was no significant difference among all the treatments. Similar trend were obtained by Singh *et al.* 2016. The result reveals that the organic carbon of soil from the both depths were significant by the intercropping of medicinal plants as compare to fruit tree sole treatments. The organic carbon content in surface soil ranged from 0.46% to 0.52%. At depth i.e. 0-15 and 15-30 cm, the highest value (0.52% and 0.49%) of organic carbon was recorded under the treatment T_2 (guava+brahmi) followed by T_4 (0.51%

Table 1. Effect of medicinal crops on bulk density and porosity of soil after the harvesting of intercrops during the year 2021

S. No.	Treatments	Bulk density (g cm^{-3})		Porosity(%)	
		0-15cm	15-30cm	0-15cm	15-30cm
T_1	Guava + Aloe vera	1.36	1.40	48.68	47.17
T_2	Guava + Brahmi	1.32	1.36	50.06	48.82
T_3	Guava + Lemongrass	1.35	1.40	49.06	47.03
T_4	Guava + Mentha	1.34	1.38	49.31	48.54
T_5	Guava + Stevia	1.37	1.40	48.30	47.33
T_6	Guava + Turmeric	1.35	1.38	49.23	48.05
T_7	Guava sole	1.39	1.42	47.67	46.42
	LSD (P=0.05)	0.03	0.02	1.09	0.87

and 0.48%) and T_6 (0.50% and 0.48%) which were grown with mentha and turmeric crops, and the lowest was recorded (0.46% and 0.42%) under guava sole treatment, respectively. This might be due to increased plant biomass production and organic matter returns to soil in the form of decaying roots, leaf-litter and crop residues which ultimately leads to higher organic carbon content on a long term basis (Jaimini *et al*., 2006; Khang *et al*., 2011 and Brar *et al.*, 2015).

Soil nutrient status (N, P and K)

Data presented (Table 3) clearly show that the availability of N, P and K of soil in both depth, were significantly higher under guava based intercropping systems in all the treatments than the guava sole. Significantly maximum available N was recorded in T_4, which was followed by T_6 and the lowest available nitrogen was found in T_7. The results of enhanced N content of soil by intercropping in mango orchard have been reported by Swain and Patro (2007). Moreover, the nitrogen content of each block of intercropped declined with the soil depth which might be due to lower leaching losses as reported by Sharma and Choudhury (2002).

Similarly, the available P and K content of soil were influenced through different intercropping systems. However, soil P content was recorded maximum under the growing of mentha crop (T4) and lower in guava sole system (T_7) at both depths. More or less, similar findings on beneficial effect of intercropping in increasing phosphorus availability in the soil have been reported by Swain and Patro (2007) and Kumar *et al*. (2009). The available K status of soil was recorded highest when medicinal crops were grown under guava based intercropping as compared to guava sole. Regarding 15-30 cm depth similar trend was noted under 0-15 cm depth. This may be due to higher microbial activities and more favorable physical condition *viz.*, soil moisture, temperature in the groundcover treatments than sole. This is supported by Vanlalhluna and Sahoo (2010), Qaisar *et al*. (2007); Jaimini *et al*. (2006); Kaur *et al*. (2002) and Menezes *et al.* (2002).

Conclusion

From the present investigation it is concluded that based on the performance of medicinal crops such as mentha, brahmi and turmeric performed superior

Table 2. Effect of medicinal crops on pH, EC and organic carbon of soil after the harvesting of intercrops during the year 2021

S. No.	Treatments	pH		EC(dSm^{-1})		Organic carbon(%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	Guava + Aloe vera	7.75	7.94	0.43	0.40	0.48	0.44
T_2	Guava + Brahmi	7.64	7.81	0.45	0.43	0.52	0.49
T_3	Guava + Lemongrass	7.70	7.89	0.46	0.45	0.47	0.44
T_4	Guava + Mentha	7.64	7.82	0.45	0.43	0.51	0.48
T_5	Guava + Stevia	7.70	7.91	0.44	0.41	0.46	0.44
T_6	Guava + Turmeric	7.65	7.86	0.47	0.43	0.50	0.48
T_7	Guava sole	7.79	7.95	0.41	0.39	0.46	0.42
	LSD (P=0.05)	NS	NS	NS	NS	0.03	0.02

Table 3. Effect of medicinal crops on available N, P and K (Kg ha^{-1}) of soil at the end of experiment

S. No.	Treatments	Available N		Available P		Available K	
		0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
T_1	Guava+Aloe vera	216.32	204.69	24.07	20.97	310.36	292.07
T_2	Guava+Brahmi	217.07	207.22	24.47	21.22	315.20	295.79
T_3	Guava+Lemongrass	210.27	196.54	24.89	21.81	302.14	285.22
T_4	Guava+Mentha	222.57	209.86	25.97	23.10	300.83	283.07
T_5	Guava+Stevia	211.55	197.65	23.86	20.30	306.67	288.70
T_6	Guava+Turmeric	219.01	206.52	25.63	22.52	309.68	292.24
T_7	Guava sole	208.41	194.60	22.86	20.04	297.45	280.41
LSD (p=0.05)		4.84	4.10	1.82	1.31	4.16	3.03

for the enhancement of soil physical, chemical environments and soil quality than rest of medicinal plants and control also. The combination of fruit orchard with herbal plants seems to improve the physical and chemical properties as well as status of macro-nutrients of orchard soil more than guava alone, probably due to more and faster decomposition of litter fall and root biomass of cover crops. Based on suitability of these intercrops under guava based horti-medicinal cropping system can be adopted to conserve soil moisture and soil health.

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