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EFFICIENCY OF MARIGOLD (*Tagetes* Spp) AS A COMPANION CROP TO DEBAR INSECT PESTS FROM THE BRINJAL ECOSYSTEM

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Pest herbivores debilitates the crops and results in the yield loss to a higher extent. Thus huge agricultural loss results into food scarcity and other socio-economic problems. Although modern crop cultivation science has adopted the biocontrol strategies for the pest killing, yet, when biocontrol fails, there is still reliance on chemical control for crop production and excessive use of chemical sprays result in resistant pest genotypes, phytotoxicity and pesticide residue problems. Injudicious application of broad spectrum pesticides results into toxic molecules entry into the vertebrate food chains and bio-magnification in the ecosystem. Thus alternative pest management strategies are adopted nowadays like use of trap crops or companion crops accompanying the main crop for the pest diversion. Companion planting is a form of intercropping, typically practiced in small-scale gardens and agricultural crop fields in which two or more species of plants are grown near each other for shared benefit. Mixed plantings with companion crops are established to boost crop productivity, diversify options for food and income generation, and improve gardens' resilience under difficult growing conditions.

French marigolds (Tagetes patula) and African marigolds (T. erecta) help to keep the insect pest away from the host plants.. It is thought that this is due to the exudates marigolds produce (thiopene and alpha-terthienyl) to stunt the growth of plants nearby which could be explained as a form of evolutionary competitiveness of marigolds over other plants. Wild marigolds Tagetes sps are highly toxic to the plant parasitic nematodes and are capable of suppressing wide range nematode pests. The plausible mode by which marigolds suppress plant parasitic nematodes is through the biochemical interaction known as allelopathy. The root exudates of marigold known to contain toxic bioactive chemicals having nematicidal, insecticidal, fungicidal, antiviral and cytotoxic activities.

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Reason for using marigold as companion crops

Marigold (*Tagetes* spp) is an excellent plant for the management of root knot nematodes, the bioactive chemicals secreted by the root exudates of marigold could effectively control the nematode population. Thus the use of marigold in nematode in nematode control is an environmentally safer and economically viable method. The roots of marigold were reported to contain flavonoids, di-hydroflavonoids, flavones and flavonones lacking a free OH group. The roots had also been reported to contain chemicals like amines, amides, phenols and ketones. More recently El-Gengaihi et al., (2001) isolated three nematicidal compounds using chloroform from Tagetes erecta, Tagetes patula and Tagetes minuta. These compounds included 5(- ent-1-ol)-2,2-bithienyl, sigma-4, 22-dien-3-beta-ol, and 5-(4- acetoxy-1-butenyl)-2,2-bithienyl. Alpha-terthienyl is heterocyclic sulphur containing compound usually abundant in Tagetes tissue. Gommers and Bakker (1988) proposed that in the absence of light, alpha-therthienyl is activated by root peroxidases synthesized when the plant parasitic nematodes puncture and penetrate the roots. Rotating the cash crop with marigold has been found to have similar effects as growing a non-host crop in reducing plant parasitic nematode population and thus may provide better efficiency than soil fumigant use to suppress nematodes.

Niall J. A. Conboy et al (2019) concluded that planting marigolds next to tomato plants protects the tomatoes from the glasshouse whitefly (Trialeurodes vaporariorum Westwood). If shown to hold true, this technique could be used in larger-scale tomato production, protecting the crop and helping to introduce greater plant diversity into these agro-ecosystems. Root (1973) ‘enemies hypothesis’ in reference explored top-down mechanisms. He proposed that natural enemy populations are greater in polycultures because diverse habitats provide a greater variety of prey and host species that become available at different times. Furthermore, the presence of a greater diversity of prey and host species allows natural enemy populations to stabilize in the companion marigold crops without necessarily debilitating the host population. According to Gupta and Bhandari,1975 , the essential oil of the leaves of Tagetes minuta was reported to contain d-limonene, ocimene, b-myrecene, aromadendrene, l-linalool, linalyl acetate, linalool monoxide, d-carvone, tagetone, 1:8 cineole and salicylaldehyde. However, Sharma et al., 1961 elucidated that the flowers of Tagetes erecta showed the presence of essential oils like d-limonene, ocimene, 1-linalyl acetate, 1-linalool, tagetone and n-nonyl aldehyde. The essential oil of the leaves, flowers and

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stems of Tagetes patula was reported to contain ocimene, limonene, linalool, linalyl acetate and tagetone (Dhingra and Dhingra, 1956). The terpenes, a-pinene, b-pinene, dipentene, menthol and geraniol were reported in the essential oil of the leaves and flowers of Tagetes erecta (Baslas and Singh, 1980).

Marigold as a companion crop in brinjal ecosystem

Marigold could be grown as a companion crop along with the brinjal as the main crop. It could be seen that the pest population loads in the main crop get reduced due to the marigold companion crops grown around the main crop brinjal. Sucking pests like jassids, whiteflies and coleopteran pests like Epilachna vigintrioctopunctata get diverted to the companion crops from the main crops, as a result the main crop gets protection to a higher degree. However, it could be seen from the companion planting of marigold along with the main brinjal crop that the brinjal shoot and fruit borer Leucinodes orbonalis population (monophagous pest for brijal) also gets reduced due to the odour emitted by the marigold plant. The average percentage shoot infestation in the main crop brinjal during the vegetative stage of brinjal gets lesser when marigold is grown around the main brinjal crop. Also, the average percentage of fruit damage in brinjal by borer pest also seen to be less during the brinjal fruiting stage when brinjal is grown with marigold as a companion crop. Below shows the average pest population per plant of the jassids, epilachna beetle,white fly, % shoot infestation in main crop, % fruit damage in the main crop bronjal in summer brinjal (March 2018 to August 2018) in Gayeshpur, Nadia, West Bengal at twenty days interval

Dates of Observation	Main crop (Brinjal)				
	Jassids	Epilachna	whitefly	% Shoot damage	%Fruit damage
29.03.2018	4.00	2.00	5.00	2%	12%
18.04.2018	3.00	1.00	4.00	3%	15%
08.05.2018	3.00	1.00	6.00	5%	11%
28.05.2018	2.00	2.00	5.00	3%	13%
Dates of Observation	Main crop (Brinjal)				
	Jassids	Epilachna	whitefly	% Shoot damage	%Fruit damage
17.06.2018	3.00	0.00	5.00	4%	15%
06.07.2018	3.00	0.00	6.00	3%	20%
26.07.2018	4.00	1.00	5.00	5%	13%
14.08.2018	2.00	1.00	5.00	10%	17%

Table 1: The data in the tables shows the average population of pests (converted to the nearest whole number)

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It could be seen from the table that the pest population per plant in the main crop brinjal was comparatively less than the average pest population per plant in the companion crop marigold during the summer brinjal crop. Also the companion crop marigold harbor quite a large number of natural enemy population like spiders, Coccinella beetle and Ants which predates on the insect-pest on the main crop. This experimental research was carried out at the Central Research Farm of the university, Gayeshpur, West Bengal (Geographical location- Latitude 23°N, Longitude 89°E, Altitude 9.75m MSL).

Yield of brinjal when grown with marigold

When brinjal is grown with the companion crop marigold, the high marketable yield of brinjal fruit is obtained. From the experimental research conducted above the marketable yield of brinjal for all the above date of observations revealed the following bar diagram for the summer brinjal crop (March 2018 to August 2018)

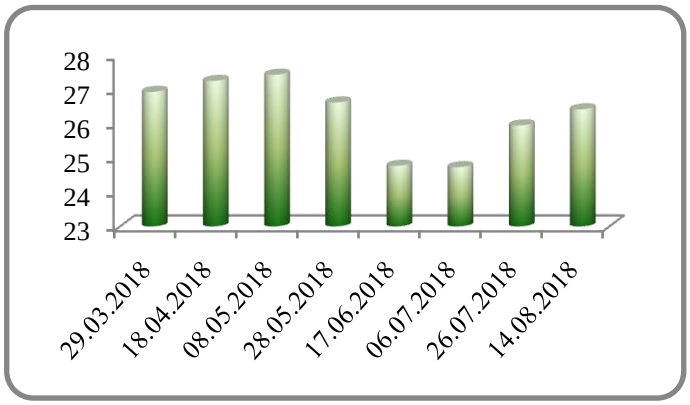

Figure 1: The bar diagram represents the marketable yield of brinjal (tonnes/hectare) on different date of observations.

The Figure-1 represents the marketable yield of brinjal (tonnes/hectare) on a different date of observations when grown with the companion crops marigold during the summer brinjal crop(March 2018 to August 2018). From the Figure-1 it could be revealed that on 29th March 2018, the total marketable yield of brinjal was 26.93 tonnes/hectare. The marketable yield of brinjal gradually increased till 8th May 2018 when it recorded highest marketable fruit yield of brinjal to the tune of 27.43 tonnes/hectare. Gradually the fruit yield of brinjal decrease thereafter when the least marketable fruit yield was recorded to be 24.73 tonnes/hectare on 6th July 2018. Then again the total marketable yield of brinjal fruits increased at on the last date of harvesting i.e. on 14th August 2018, the marketable yield of brinjal was recorded to be 26.42 tonnes/hectare.

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Conclusion

Many studies have reported a wide variety of companion plants to contain repellent properties. Companion plants have also been reported to alter the chemical profile of the targeted ecosystem. For example, certain companion plants can directly affect adjacent plants by chemicals taken up through its root. African marigolds (Tagetes spp.) produce root exudates which can be absorbed by neighbouring plants and may help to explain the reports of African marigold reducing pest numbers. African marigolds also release thiopene, which acts as a repellent to a plethora of nematodes. Similarly, empirical studies of the marigold as a companion plant along with the main crop brinjal in field situation revealed that the pest populations from the main crop got diverted due to marigold repellents in the leaves and flowers. While the companion crops(marigold) in the marigold+brinjal ecosystem harbored plethora of natural enemies which essentially fed upon the soft bodied pests, thus, volatile interactions between odors of host and non-host plants and even single species with different cultivars can affect the behavior of pest insects.

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