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# Role of Intercropping Some Aromaticand Medicinal Plants with Fruit Vegetables Crops, a Review

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**Abstract:** Crop diversification, need to maintain current levels of cropped area for food and otheruses have made use of intercropping important. The trap nature of medicinal aromatic plants and has a great role for vegetable crops important for protecting damage of fruits from insect pest attack, extend the shelf life of it, maintain the quality during transportation to market like African marigold. Intercropping of medicinal and aromatic plants with different horticultural plants has a great role reducing the post-harvest yield loss, maintain the quality of fruits and increase its shelf life in storage. The aromatic nature and essential oil of Medicinal aromatic plants (MAPs) enables to protect soil borne nematodes; they also protect these nematodes diseases by suppressing its adventus root system. The presence of other crops in intercropping the volatile oil is reduced because of shade. However, shading of the component crops has a negative effect on essential growth, biomass yield, oil content, composition and quality oil of MAPs. Medicinal aromatic plants are also significantly increase soil organic nitrogen, soil water content, decreased pH values and available nitrogen content. Intercropping of MAPs with other crops offers congenial conditions which it results the improvement in resource use efficiency in terms of productivity and net return per unit area.

**Key words:** African Marigold · Essential Oil · Fruits · Maps and Vegetables

## INTRODUCTION

Plants with aromatic qualities contain volatile oils that may interferewith host plant location, feeding, distribution and mating in decreasedpest abundance [1, 2]. According to the experimental result of Khafagy [3] intercropping of some aromatic plants with tomato protect the infestation of *Tuta absoluta* on tomato. The inclusion of rosemary with onion elevated yield advantage and competitiveness oversole planted crop per unit area as indicated by higher land equivalent ratio andrelative crowding coefficient. This enables to prevent the insect pest attack on onion [4]. Planting marigolds between tomatoes protects the tomato plants from harmful root-knot nematodes in the soil and increasethe marketable fruit yield of tomato by trapping different insects and pest attack and the like [5]. Marigold repels nematodes, tomato worm, slugs and general garden pests. Gomez Rodriguez *et al*. [6] found that intercropping of tomato with African marigold (*Tagetes erecta* L.) reduced early blight (*Alternaria solani*) of tomato in three ways: (1) allelopathic effect on Alternaria solani development, (2) reduced humidity levels below those conducive to thepathogen requirement and (3) behaved as a physical barrier against spore dispersal [6, 7]. Intercropping marigold fornematode management also appeared to reduce numbers of aphids and whiteflies and resultedin lower levels of virus in tomato [7].

Diversification of crops, the need to maintain current levels of cropped area for food and otheruseshave madeuse of intercropping important. This system but also economy, equity andopportunities for knowledge based rural enterprise. Thus, research has to be directed towardsincorporating medicinal and aromatic crops (MACs) in existing cropping systems such as intercrop, crop rotations, under crops etc. there is an excellent body of literature on theimproved cropping systems involving Medicinal Aromatic Crops (MACs) [8]. Medicinal aromatic crops short duration vegetables grown in-between the aromatic crops isthe recent

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advancement to fulfill the requirement of vegetables without any reduction ofproduction area. Performance of coriander Chellaiah *et al.* [9] and other crops likevegetables, fodder, pulses and cereals Verma *et al*. [10], Singh *et al*. [11] Rao Rajeswara [12] as intercrops under different cropping situation are well documented. Medicinalaromatic crop-based cropping systems in north and south India has shown that farmers gainsignificantly higher profit from their lands [13, 14].

These systems have not only influenced the economics but also paved way for agro-basedenterprises in the regions. Short duration vegetables grown in-between the aromatic crops isthe recent advancement to fulfill the requirement of vegetables without any reduction ofproduction area. Plants with aromatic qualities contain volatile oils that may interfere with host plant location, feeding, distribution and mating in decreased pest abundance [1, 2]. Khafagy [3] reported that, intercropping system of kidney bean with sweet basil, geranium, peppermint, spearmint and hot pepper showed highly reduction of *Bemisia tabaci* (Gennadius) (eggs, nymphs and adults) compared to kidney bean sole. Nan-host volatiles have been found to be repellent and/ or deterrent for a number of insect species in various insect orders: Coleoptera [15, 16], aphids (Homoptera: Aphididae) [17-20, Lepidoptera [21-23], Diptera [24] and Hymenoptera [25]. The odors given off a non-host plant repel the searching insects. Aromatic plants have been suggested to be particularly repellent for host seeking insects [1]. The experimental result of Wondimkun and Ketema [5], which revealed that cropping system does not have significant effect on number of fruits per plant in tomato-African marigold intercropping.

Intercropping African marigold at 50% population density significantly increased tomato totalfruit yield by 0.27% as compared to 25% population density of African marigold by 0.22%. The experimental result of Yayock [26] that showed fruit yield of tomato was increasedas population density increased, but after certain point it starts to decline its yield because theincreasing of interspecific competition among the component crops (the demand crops formoisture, nutrient and solar ration might beyond the available resources on a given area) so itis better to know the optimum planting density among the component crops. This might be dueto the risen of interspecific competition among the component crops. Plant density significantlyaffected the interspecies dynamics of the component crops in intercropping Rena *et al*. [27] and Pal *et al*. [28], as it is a major factor affecting the intercropping system of the componentcrops in terms of yield. This related to interspecies competition for soil moisture, nutrients, light and other common resources. This experiment showed that yields of component crops in the intercropping system vary significantly with the components population density. This result was disagreed with the reported results of Tesfaye [29] Law-Ogbomo and Egharevba [30] they reported that highest total fruit yield per hectare of tomato was obtained from lowplant density than at high plant density (fruityield of tomato was decreased with increased population density).

The experimental result Ashraf *et al*. [31] indicates that intercropping ofpomegranate with aromatic plants (sweet basil and rosemary) at different intercropping systems affects growth and productivity of the three species (pomegranate and aromatic plants) and also the competitive indices of the cropping system. It also revealed that the combined yield advantages in terms of land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE) were greatest when pomegranate intercropped with somearomatic plants.

The cropping system of MAPs with other horticultural crops has a great impact of soil conservation, harvesting natural products, avoid environmental pollution and maintain the quality and shelf life of fruits and vegetables. So, the main objective of this review paper is to assess the intercropping system of some medicinal and aromatic plants with vegetable and fruits.

## Literature Review

**Review Intercropping System of Some Medicinal Aromatic Plants with Some Vegetable Fruit Cropsintercropping Chamomile with Other Vegetables:** Chamomile (*Matricaria recutita* L.) is an annual species naturally distributed in theMediterranean basin, but it also grows naturally in several areas of Europe, Asia, India, Algeria, Siberia, Australia and the Americas. It is cultivated in temperate countries such as Germany, Hungary, Russia, Kashmir, Lebanon, Argentina, Colombia and elsewhere.It thrives in all types of soil acidity, but performs better in soils with high pH values. It canalso be grown in clayey, shallow and moist soils, while it grows better in soils rich in organic matter and temperatures from 7 to 26°C [32].

Medicinal and aromatic plants are of prime economic importance because of the continuous and increasing demand for their products by local and foreign markets [33]. German chamomile (*Chamomilla recutita* L.) Rauschert is one of the most important plants in this

regard [34]. Nowadays, in phytotherapy, flower anthodia are mainly used. Pharmacological properties include anti-inflammatory, antiseptic, carminative, healing, sedative and spasmolytic activity [34]. According to Ahmadian *et al.* [35], essential oil content and composition of essential oil in plant varies and is due to the genetic and environment factors, such as water stress and nutrient fertilizers. According to the experimental result of Darbaghshahi *et al.* [36], chamomile and Saffron has similar agroecology requirement in mixed culture. Generally, the trapping nature of chamomile enables to protect the very sensitive vegetable crops like tomato, cabbage and potable as push-pool technology in intercropping.

**Effects of Intercropping of MAPs on Soil pH and Organic Matter:** Intercropping with certain species of aromatic plants can improve soil quality. It is also significantly increase soil organic nitrogen, soil water content, decreased pH values and available nitrogen contents in our previous study [37]. However, intercropping vegetables with aromatic medicinal plants is not well studied and known in different parts of the world like pulse withcereals.Intercropping of MAPs had more positive effect on soil pH in medicinal aromatic plants with vegetable fruit crops. The experimental results of Sujatha *et al*. [38], revealed that the soil pH was increased from 0.9-5.6 in 2004 units due to the presence of medicinal aromatic plants. Soil organic carbon (SOC) content is also varied significantly due to intercropping of MAPs at the end of this experiment. The soil organic carbon (SOC) content increased in Aloe vera, A. pallens, P. longum and *B. monnieri*, while it depleted in grasses and rhizomatic MAPs. The demand and marketing opportunities for MAPs, farmers are advised to grow aromatic plants in large areas on a community basis to meet huge industrial demand and variety of medicinal crops in small areas to meet the requirement of traditional systems of medicine.

**Intercropping African Marigold with Tomato:** Members of the genus *Tagetes* have a long history of human use as beverages, condiments, ornamentals and medicinal purpose such as analgesics, antiseptics, carminative, diuretic, antispasmodic, anthelmintic, stimulants, vermin repellents and for treatment of stomach and intestinal diseases [11, 39]. *Tagetes minuta* L., commonly known as African marigold, is a highly aromatic annual perennial herb growing. It is cultivated for '*Tagetes* oil' [11]. African marigold is used in indigenous medicines as a natural source of raw material due to its anti-microbial, anti-inflammatory, anti-fungal and insecticidal and acaricidal activities [40, 41]. Marigold and tomato companion planting is a tested and true technique used by gardeners for hundreds of years. Research studies have indicated that planting marigolds between tomatoes protects the tomato plants from harmful root-knot nematodes in the soil. Although scientists tend to be skeptical, many gardeners are convinced that the pungent scent of marigolds also discourages a variety of pests such tomato hornworms, whiteflies, thrips and maybe even rabbits. Allow 45 to 60 cm between the marigold and the tomato plant, which is close enough for the marigold to benefit thetomato, but allows plenty of space for the tomato to grow (https://www.gardeningknowhow.com/ornamental/flowers/marigold/marigoldtomatocomanions.htm). Marigold repels nematodes, tomato worm, slugs and general garden pests. Gomez Rodriguez *et al.* [6] found that intercropping of tomato with African marigold (*Tagetes erecta* L.) reduced early blight (*Alternaria solani*) of tomato in three ways: (1) allelopathic effect on *Alternaria solani* development, (2) reduced humidity levels below those conducive to the pathogen requirement and (3) behaved as a physical barrier against spore dispersal [6, 7]. Intercropping marigold for nematode management also appeared to reduce numbers of aphids and whiteflies and resulted in lower levels of virus in tomato [7].

The most common leaf disease in tomato is tomato early blight, caused by *Alternaria solani*. This disease is considered one of the main diseases affecting tomato production in different area of the world. According to different authors [6, 7, 42], the effects of marigold intercropped with tomato on *Alternaria solani* on tomato leaf damage was observed in farm condition. Three reasons were given for this. The first was the allelopathic effects of marigold on *Alternaria solani* conidia germination. The second was by altering the microclimatic conditions around the canopy, particularly by reducing the number of hours per day with relative humidity > 92 %, thus diminishing conidial development. The third mechanism was to provide a physical barrier against conidia spreading. For intercropped with tomato, African marigold plants serves as a physical barrier and promoted reductions in the maximum relative humidity surrounding the canopy, but to a lesser extent than marigold [6, 42]. The experimental results of Wondimkun and Ketema [5]; Wondimkun and Desta [43] which revealed that intercropping of African marigold varieties at 50% population densitywithtomato gave effective land utilization efficiency and more profitability. Intercropping

of African marigold with tomato adds extra income and warrants insurance against a risk to the farmers, intercropping of tomato component was found to be advantageous than single cropping of tomato as there is a scarcity of land and a need to diversify production. They also conclude that intercropping of African marigold and other aromatic and medicinal plants with other known crops like tomato is one of the best options toincrease the production of African marigold in Ethiopia [5].

**Intercropping Basil with Tomato:** Tomato and basil are common pairs that are intercropped [44]. Several studiesreported theperformance of inter-cropping of aromatic and medicinal plant species with selected major horticultural crops in different countries as cited by Midekesa and Chala [44], the experimental results of Neelam and Lokho [45], Nigussie *et al*. [46], Girma [47], reported inter-cropping of onion with basil at a 1:1-row arrangement couldprovide farmerswith the best yield advantage and income over sole planting of component (onion) crops.Basiland tomato are companion plants that have similar lighting and watering needs, someeven say tomatoes tastebetter when they neighbor basil [48]. According to Lulie [49], higher tomato yields havebeen observed under intercropping with Aromatic plants as compared to tomato alone, so it is a more profitablesystem. Previousresearch has also observed that Basil can attract the positive bacteria, *Arbuscular mycorrhizal* fungi (AMF) and helps prevent diseases in tomatoes and increases the biomassof tomato [50]. The efficiency of intercropping tomato with basil was significantly affected by basil population density androw arrangement. Intercropping of basil with tomato enables to obtained the highest economic value [44]. Medicinal and aromatic plants (MAPs) play a significant role in the uplifting rural economy and thus, their demand is increasing all over the world [12, 51]. However, they are less cultivated by farmers, because their cultivation as a mono-crop involves certain risk and their economic returns are uncertain. The productivity of tomato and basil intercrops requires improving the interspecies complementary action or reducing the competition effects. Planting density is one of the most important agronomic management decisions to be considered when deciding to practice intercropping. The experimental results of Sattler and Bartelheimer [52], revealed that poor management of planting density could be detrimental to intercropping. They also stated that the lowest plant densities may limit the potential yield of the main cropbut the highest plant densities may lead to increased stress on the plants and increased interplant competition for light, waterand nutrients finally it results decreased the yield [53].

**Intercropping Rosemary with Carrot and Onion:** The experimental Nibret [54] revealed that intercropping rosemary with carrot showed that intercropping 25% and 50% of rosemary with 100% carrot gave significantly higher in terms of monetary advantage index. These experimental results also showed that carrot rosemary cropping system enables to obtained the additional income generation for small scale farmers and intensive agriculture system. Intercropping of rosemary with onion has also a great role for additional income generation of the component crops. Intercropping onion with the vegetables reduced boththe total and marketable bulb yield. The highest bulb yield and other agronomic traits to obtained from the highest plant population density of rosemary in rosemary onion intercropping [55]. Similar results were reported by Talukder *et al.* [56], Trdan *et al*. [57], Kabura *et al*. [58] and Kucharczyk and Legutowska [59], who revealed that intercropping onion with coriander increase bulbyield and carrot yield with the increased population density. The experimental results of Ofosu-Animand Limbani [60], who reported that the lowest bulb yield was obtained with the increased rosemary population density, this may due to the highest plant density per plot area of rosemary and intercropcompetition for nutrients, water and light. The increasing pressures onagricultural land arisen out of population growth, farmershave to explore new ways to intensify production per unitarea of land [54].

The pest occurrence is a severe problem in vegetable cultivation. There is growing public concern about the non-target effects of pesticides on humans and other organisms and many pests have evolved resistance to some of the most commonly-used pesticides. Monoculture farms do not provide the resources for natural enemies to provide natural control services [61]. The intensive cropping of carrot and indiscriminate use of pesticides are annihilating natural enemies. The synergetic effect of MAPs and carrots, have led to increasing interest in non-chemical, ecologicallysound ways to manage pests. So, this cropping system the best pest-management alternative because the diversification of agricultural fields by establishingpolycultures (mixed cropping, intercropping, undersowing, etc.) that

include one or more different crop varieties or species within the same field, to more-closely match the higher species richness typical of natural systems [62]. The percentage of plants damaged by the carrot rust fly Psilarosae (F), root aphids Pemphigus phenax Band B, haworth carrot aphid Dysaphiscrataegi Kalt and nematodes was reduced due to the presence of medicinal aromatic plants [61]. Intercropping of MAPs had a significant effect on the decrease in the number of fruits, roots and leaf damaged rust fly Psilarosae, aphid, fungi and other soil born nematodes [62]. The experimental results of different authors suggested revealed that during harvest the least number of damaged roots were observed in combination with of MAPs with other vegetable and fruit crops. The experimental results of Jankowska [62], showed that the number of carrot psyllid *T. viridula* Zett. and aphids on carrot leaves and roots damaged by nematodes was significantly lower on plots where carrot was intercropped. In all years the highest number of Coccinellidae and Syrphidae was also observed on plots where carrot was intercropped with coriander.

**Intercropping of Mint with Other Fruit Crops:** As cited by Paulus *et al*. [63] which revealed that agroforestry contributes throughthe intentional incorporation of woody vegetationwith agricultural crops, grasses, or livestock inthe same land unit, to produce ecologicalfinancial and social benefits[64]. Intercropping of medicinal plants in agroforestry systems has become a best choice for the integration of forest species with species of agricultural use. The presence of aromatic and medicinal they allow sustainable production, avoiding contamination of the soil with agrochemicals that can alter the composition of the active components of medicinal plants [65]. The inclusion of aromatic and medicinal plants in agricultural farms is important for sustainable use and management technologies that reduce environmental impacts and thatcan make this production system socially and economically feasible. The Mentha (Lamiaceae) family comprises plants such as mint which are highly cultivated due to the productionof essential oils produced by glandular trichomespresent in the leaves and stems of plants [63]. Besides of the trapping nature and increase the soil nutrients, the essential oils of mint are directly used as food flavourings, flavouring agents, cosmetics, perfumes and medications [67]. The Mintfamily like pepper mint, spear mint, Japan mint and others which enables to produces essentialoils that rich in monoterpenes, such as linalool. Thiscomponent is of great economic interest becauseit is widely used to fix fragrances, about 70 % of the cosmetics produced in the perfumeindustry have linalool in its formula [63].

The cultivation of medicinal aromatic plants in agroforestry silvoarable systems is possible with highquality products of the component crops in the intercropping system [68]. The cultivation of MAPs has multiple advantages over various other crops. Medicinal aromatic plants (MAPs) offer higher yield per unit area and are less likely to be attacked by insects and diseases. The inclusion of this plants can upgrade poor and unprofitable soils, yield long-term products and ensure profit for farmers [38]. The most suitable MAPs for intercropping with trees are those that develop a deep root system and are shade-resistant [68]. This may because of the competition that will be developed between the trees and the understory crop for sunlight and soil moisture. Intercropping some MAPs with trees produce better yields when grown in agroforestry systems, such as species of the genus Mentha, *Cymbopogon martini* (Roxb.) W. Watson, *Cymbopogon flexuosus* (Nees ex Steud) Wats. and Piper longum L. in avocado, papaya, coffee plantation farms [69]. However, the population density of tree affects the growth, biomass yield chemical composition and quality of some medicinal aromatic plants. So, the appropriate choice of the understory MAP species has a significant impact on the success of the agroforestry system [68].

**The Effects of Intercropping Aromatic Medicinalplants with Other Horticultural Crops on its Essential Oil Content and Oil Yield:** The results of different intercropping researches showed that increased essential oilcontent in aromatic plants with increased essence rate of the oil [70]. This may due to the low volatile rate of essential oils due to the presence component crops (shade). The transpiration rate influencesconcentration as well as the composition ofessential oils this is directly related to the volatile aromatic oil of the plants from solar radiation. The development of glandulartrichomes, plant structures that biosynthesizeand store essential oils, is a light-dependentprocesses [71]. The low light intensity and lowtemperatures cause significant variations in theamount of essential oil constituents and total yield [63]. According to Costa *et al*. [70], the ratio of lightquality and composition of peppermint oil (Mentha piperita) may be associated with thebiosynthetic

route of the compounds, as theconversion of menthone to menthol is influencedby low light and short photoperiod conditions.The cultivation of mint with bananas showed thelowest production of biomass and essential oil, possibly due to excessive shading, because thebananas had large leaves that provided greatershading than the other evaluated fruit species [72]. The essential oil of lemon balm was also (*Melissa officinalis* L.) reduced when intercropped with black mesh due to shading presented less fresh and dry weight development and lower essential oil content. The desired characteristics in therapeutic plantsare the Phyto mass and the active component, and if intercropping increases the productivity ofthe agroecosystem and maintains localbiodiversity, favoring the natural control of pestsand diseases, as well as the recycling ofnutrients [73]. The cultivation of medicinal plantsassociated with fruit, becomes a viablealternative.

**Role of Medicinal and Aromatic Plants for Post-Harvest Yield Loss:** Cultivation of medicinal and aromatic plants (MAPs) has several advantages like higher net returns per unit area, low incidence of pests and diseases, improvement of degraded and marginal soils, longer shelf life of end products and foreign exchange earning potential [38]. Regardless of this, the lack of standardized cultivation aspects, supply of good quality planting material and marketing facilities are identified as major limitations in cultivation of MAPs [74]. The quality of the economic products of MAPs is an absolute necessity. As the demand for organic products is increasing rapidly in the world market, adoption of organic farming approach would be a feasible option. The experimental results of different researches showed thatMAPsmaintain the quality of the fruits and vegetables of the component crops in the intercropping system. African marigold flower maintains the quality of tomato fruit in storage and transportation.

## CONCLUSION

Medicinal and aromatic plants are of prime economic importance because of the continuous and increasing demand for their products by local and foreign markets. Intercropping of medicinal and aromatic plants with different horticultural plants has a great role reducing the post-harvest yield loss, maintain the quality of fruits and increase its shelf life in storage. The essential oil content, oil yield and composition of MAPs is also affected by interspecific competition of the component crops intercropping system. The inclusion of MAPs enables to prevent the damaged of fruits, insect pest attack of vegetables fruits. Plants with aromatic qualities contain volatile oils that may interfere with, host plant location, feeding, distribution and mating, resulting in decreased pest abundance. Intercropping of medicinal plants with horticultural crops; Enables to expand the area coverage and production of MAPs increase the adoption rate of different research technologies from such type of crops. Hence the insect trap nature of some MAPs it has a great role for vegetable crops like tomato, cabbage, potato, onion and other fruit crops.Intercropping with certain species of aromatic plants can improve soil quality. It is also significantly increase soil organic nitrogen, soil water contentdecreased pH values and available nitrogen content. Intercropping of MAPs with other crops offers congenial conditions which it results the improvement in resource use efficiency in terms of productivity and net return per unit area.

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