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Effect of intercropping on growth and yield of tomato (*Solanum lycopersicum* L.)

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ABSTRACT:

The investigation was carried out to "Study the effect of intercropping on growth and yield of tomato (Solanum lycopersicum L.)" at a farmer's field at Sorakalnatham, Natrampalli taluk, Tirupattur district, (Tamil Nadu) during January - May 2019. The experiment was laid out in randomized block design with ten treatments replicated thrice. The treatments comprised of three intercrops viz., radish, small onion and vegetable cowpea, and three levels of recommended dose of fertilizers (RDF) viz., 100, 125 and 150 % along with sole crop of tomato under 100 % RDF. The results indicated that the maximum values for growthattributes viz., plant height at 30, 60 and 90 DAT (48.5, 63.5 and 92.1 cm, respectively), primary branches/plant (11.5), leaf area index (3.58) and yield components like fruits plant^{-1} (35.5), single fruit weight (82.9 g) and weight of fruits plant^{-1} (2.9 kg) were recorded in the plots which received 25 t FYM ha^{-1} + 150 % RDF in tomato + small onion intercropping system. This was followed by thetomato + vegetable cowpea intercropping system which received 25 t FYM ha^{-1} + 150 % RDF.

Keywords: Tomato, small onion, vegetable cowpea, intercropping, FYM, inorganic fertilizers, growth, yield.

INTRODUCTION

Vegetables play a vital role in Indian economy and sustain the livelihood of a large section of population either directly or indirectly. Vegetables are usually higher in productivity than the other crops. These crops can provide more food per unit time and area of land. Increased production and consumption of horticultural crops particularly vegetables with its wide adoption provides important nutrients and also offers promise for the future. Intercropping is a multiple cropping practice which involves growing two or more crops in proximity with intensification in both space and time wherein the competition between crops may occur during a part or whole of crop growth period. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources or ecological processes that would otherwise not be utilized by a single crop. Intercropping gives higher income per unit area than sole cropping, It acts as an insurance against failure of crop in abnormal year, Intercrop maintain soil fertility as the nutrient uptake is made from both layer, reduce soil runoff, total biomass production per unit area per time is increased because of fullest use of land as the inter row space will be utilized which otherwise would have been used for weed growth. It also helps in controlling weeds and control the growth of pathogens and pest in crops.Among the various vegetables, tomato (*Solanum lycopersicum* L.) which belongs to family Solanaceae is one of the most popular and widely grown nutritious vegetable all over the world. It is a very good source of income for small and marginal farmers. It is a highly perishable fruit and so the market value is less. The income of the tomato farmers can be increased through introduction of intercropping practices. Development of proper intercropping system is one of the proper approaches to improve the profitability of the farmers.In view of the above facts, a study was formulated to find out the effect of intercropping on growth and yield of tomato and effect of fertilizer regime on various intercropping systems.

MATERALS AND METHODS

The experiment was conducted at farmer's field at Sorakalnatham, Natrampalli taluk, Tirupattur district (Tamil Nadu) during January – May 2019. The experimental field is situated at 12^0 35' N latitude and 78^0 30' E longitude, at an altitude of 195.75 meters above mean sea level.The weather at Sorakalnatham is

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colder during winter and hotter in summer due to hills and forests surrounding the town. The soil was sandy clay loam in texture having pH 7.3, organic carbon 10.1 g kg^{-1}, available N 288 kg ha^{-1}, P 12.5 kg ha^{-1}, K 393 kg ha^{-1} The varieties chosen for the crop were tomato (Shivam F_1 hybrid), radish (Pusa Chetki),small onion (Rose Local) and vegetable cowpea (Pusa Komal). The experiment was laid out in a randomized block design with three replications and ten treatments *viz*.,tomato with 100 % RDF(200 kg N + 250 kg P_2O_5 + 250 kg K_2O ha^{-1}), tomato with 100 % RDF + radish, tomato with 100 % RDF + small onion, tomato with 100 % RDF + vegetable cowpea, tomato with 125 % RDF+ radish, tomato with 125 % RDF + small onion, tomato with 125 % RDF + vegetable cowpea, tomato with 150 % RDF+ radish, tomato with 125 % RDF + small onion, tomato with 125 % RDF + vegetable cowpea,Simultaneously in addition to these ten treatments, sole crops of radish, small onion and vegetable cowpea were also raised with three replications. Twenty five tonnes FYM $ha^{-1}$was applied to all the treatments before transplanting. The entire dose of phosphorus and potassium and half dose of nitrogen were applied basally and the remaining half dose of nitrogen was applied at 30 days after transplanting.Twenty five days old tomato seedlings from the nursery were transplanted by adopting 60 x 45 cm spacing. The intercrops were sown ten days after transplanting of main crop and grown in between two rows of tomato. Two rows of radish (at spacing of 15 x 10 cm with plant population of 60 plants per bed) and one row of vegetable cowpea (at spacing of 45 x 15 cm with plant population of 20 plants per bed) were sown. Similarly the bulbs of small onion were transplanted in two rows (at spacing of 20 x 12 cm with plant population of 50 plants per bed). Irrigation was given immediately after sowing with care. Life irrigation was given on third day after sowing. Subsequent irrigations were given at 7-10 days interval as per the crop requirement. In tomato, light red maturity stage of fruits were harvested for calculating the yield per plant; radish was harvested when the soil near the base of the edible roots shows cracking and a portion of the root rises above the ground level and roots were fully grown but tender. Small onion was harvested when tops were drooping but still green. Vegetable cowpea was harvested fifteen days after pod setting when the pods are longer, less fibrous and more succulent. Observations were taken on the five randomly selected plants in each plot in respect to growth characters *viz.,*plant height, number of primary branches, leaf area index, dry matter production and yield characters *viz.*, days taken for fifty per cent flowering, number of flower clusters $plant^{-1}$, number of $fruitplant^{-1}$, fruit diameter, single fruit weight, fruit yield $plant^{-1}$, and fruit yield.Biometric observation on intercropswere taken on yield and yield attributes*viz.,*root length, root diameter, root weight per plant, root yield per plot, root yield hectare in radish. Bulb length, Bulb diameter, bulbs per plant, Individual bulb weight, bulb yield per plant, bulb yield per plot, bulb yield per hectare in small onion. Pod length, Pod diameter, pods per plant, individual pod weight, pod yield per plant pod yield per plot, pod yield per hectare in vegetable cowpea.

RESULTS AND DISCUSSION

Growth attributes

The results (Table 1) revealed that there was significant difference between the treatments. The maximum values for the growth parameters *viz.,* plant height at 30, 60 and 90 DAT (48.5 cm, 63.5 cm and 92.1 cm, respectively), and number of primary branches (11.5), leaf area index(3.65) and dry matter production (241.85 g) were recorded in the plots which received the soil application of 25 t FYM ha^{-1} + 150 % RDFin tomato intercropped with small onion. This treatment was closely followed by the treatment 25 t FYM ha^{-1} + 150 % RDFin tomato intercropped with vegetable cowpea and found to be on par with the best treatment. The tallest plant heightof tomato in association with small onion is due to the promoted growth of tomato in intercropping system whereas inhibited that of small onion. These results revealed that interspecific competition occurred, and tomato had higher competitive ability than small onion when they were grown together and also tomato/ potato onion intercropping might be an efficient strategy for tomato production (Wu *et al.* 2016). The number of primary brancheswas found to be the maximum in tomato intercropped with small onion. Plants grow in dense vegetation at the risk of being out-competed by neighbours. To increase their competitive power, plants display adaptive responses, such as rapid shoot elongation (shade avoidance) to consolidate light capture (Keuskamp *et al.,* 2010).

The highest leaf area index was recorded in the treatment tomato + small onion intercropping system. The difference in leaf area among the treatments may be due to the spacing between rows, light interception and other complementary effects. All the intercropping treatments had higher leaf area index when compared with monocropping. Productivity rates increased with LAI because of increased total light interception (Brintha and Seran, 2009).Dry matter production is an important prerequisite for higher yield as it signifies photosynthetic ability of the crop and also indicates other synthetic process during developmental sequences. Application of 25 t FYM ha^{-1} + 150 % RDF in tomato intercropped with small onion had recorded the maximum dry matter production. This was probably due to uptake of nutrients which increased growth and hence provided greater translocation from leaf to shoot. The root dry weight, shoot dry weight, and phosphorus uptake in the shoot of tomato were significantly higher in intercropping system than those in monoculture system (Wu *et al.,* 2016).

Table 1: Effect of intercropping and fertilizer doses on growth parameters in tomato

Treatments	Plant height (cm)			Primary branches/plant	Leaf area index	Dry matter (g plant^{-1})
	30 DAT	60 DAT	90 DAT			
Tomato with 100 % RDF	35.2	48.4	70.3	7.0	2.81	196.70
Tomato with 100 % RDF + radish	27.4	37.9	55.4	5.5	2.40	177.20
Tomato with 100 % RDF + small Onion	32.5	45.5	66.0	6.3	2.63	186.89
Tomato with 100 % RDF + Veg. cowpea	30.7	43.5	63.2	6.1	2.59	183.99
Tomato with 125 % RDF + radish	37.6	51.3	74.4	7.9	2.99	206.42
Tomato with 125 % RDF + small onion	41.8	56.0	81.3	9.1	3.21	219.25
Tomato with 125 % RDF + Veg. cowpea	40.3	54.1	78.4	8.9	3.17	216.13
Tomato with 150 % RDF + Radish	44.3	58.9	85.4	10.1	3.40	228.95
Tomato with 150 % RDF + Small Onion	48.5	63.5	92.1	11.5	3.65	241.85
Tomato with 150 % RDF + Veg. cowpea	46.9	61.7	89.5	11.2	3.58	238.75
S.Ed	0.93	1.21	1.73	0.23	0.08	4.37
CD(p=0.05)	1.95	2.54	3.64	0.47	0.17	9.18

Veg. Cowpea=Vegetable cowpea

Yield and its attributes

Application of 25 t FYM ha^{-1} + 150 % RDF in tomato intercropped with small onion had excelled other treatments by recording the highest values for number of flower clusters plant^{-1} (12.4), number of fruit plant^{-1}(35.5), single fruit weight (82.9 g), fruit diameter (5.6 cm), fruit yield plant^{-1}(2.96 kg), and fruit yield hectare^{-1} (99.16 t). This was followed by the treatment which received 25 t FYM ha^{-1} + 150 % RDF in tomato intercropped with vegetable cowpea.The treatment tomato + radish intercropping system which received 25 t FYM ha^{-1} + 150 % RDFas soil application had recorded the earliest flowering (29.7 days) followed by the treatment T_4 (32.1 days). The days taken for 50% flowering was found to be the maximum in tomato + small onion intercropping system (49.0 days), which received 25 t FYM ha^{-1} + 150 % RDFas soil application and was on par with tomato + vegetable cowpea intercropping system. The earliness to flowering in the best treatment might be due to the better translocation of nutrients to the aerial parts. Maximum photosynthetic activity and accumulation of number of fruits might be due to increased number of flowers which might have formed into fruits due to adequate availability of major and minor nutrients during its growth and development (Laxmi *et al.,* 2015).

Intercropping tomato with small onion increased the yield of tomato, and improved soil quality by changing the soil enzyme activities and microbial communities (Zhou *et al.,* 2011). The intercropping system with small onion which by virtue of its small root and shoot system might have been advantageous for growth and development of tomato. Similar result was observed by Suresha *et al.* (2007). The highest tomato fruit yield recorded for this treatment is consistent with the maximum presence of N, P, K, Ca and Mg in the soil and tomato leaf

(Adekiya and Agbede, 2009). Besides organic manures in terms of FYM in combination with inorganic fertilizers improved the soil physical conditions and increased nutrient availability resulting in increased yield of tomato (Rafi *et al.,* 2005).Improved biometric characters namely plant height, number of branches, number and weight of fruit, possibly contributed to the higher fruit yield under the said combination (Yumnam *et al.,* 2017).Singh and Asrey (2005)reported that major nutrients are being important constituents of nucleotides, proteins, chlorophyll and enzyme, involve in various metabolic process which have direct impact on vegetative and reproductive phase of the plants. Better performance of the yield attributes of intercropped tomato might be due to higher nutrient uptake, higher photosynthetic assimilates production and effective partitioning of source to sink. Wszelaki (2014) stated that the practice of intercropping can make benefits in a crop production system by decreasing insect pest infestation, lowering external inputs, enhancing biodiversity, increase yield and reduce economic risk.

Table 2: Effect of intercropping and fertilizer doses on yield attributes in tomato

Treatments	Time taken for 50% flowering (days)	Clusters plant^{-1}	Fruits plant^{-1}	Fruit diameter (cm)	Single fruit weight (g)	Estimated fruit yield (t ha^{-1})
Tomato with 100 % RDF	36.0	10.3	30.7	4.0	72.8	77.48
Tomato with 100 % RDF + radish	29.7	9.3	28.2	3.3	67.5	64.28
Tomato with 100 % RDF + small onion	33.5	9.9	29.5	3.7	70.2	71.09
Tomato with 100 % RDF + Veg. cowpea	32.1	9.8	29.4	3.6	70.0	68.78
Tomato with 125 % RDF + radish	38.5	10.8	31.8	4.3	75.3	81.82
Tomato with 125 % RDF + small onion	42.6	11.4	33.1	4.8	77.9	87.16
Tomato with 125 % RDF + Veg. cowpea	41.0	11.3	33.0	4.7	77.8	86.17
Tomato with 150 % RDF + radish	45.1	11.8	34.2	5.1	80.4	93.76
Tomato with 150 % RDF + small onion	49.0	12.4	35.5	5.6	82.9	99.16
Tomato with 150 % RDF + Veg. cowpea	47.5	12.3	35.4	5.5	82.9	98.49
S.Ed	0.91	0.20	0.54	0.13	1.18	1.65
CD(p=0.05)	1.91	0.43	1.14	0.27	2.48	3.47

Biometric observations on intercrops

Yields attributes and yield of redish

The data recorded on yield attributes and yield of radish are presented in Table 3. The maximum yield and yield attributes of radish *viz.,* root length (11.4 cm), root diameter (4.14 cm), root weight per plant (80.05 g), root yield per plot (46.39 kg) and root yield (30.68 t ha^{-1}) were recorded in sole stand of radish. The radish grown within tomato inter rows along with 25 t FYM ha^{-1} + 150 % RDFfavourably registered higher root length of 11.05 cm, root girth of 4.08 cm, root weight per plant 77 g, root yield per plot 13.76 kg, root yield 9.10 t ha^{-1} over other treatments. Radish raised with tomato under intercropping system along with the application of 25 t FYM ha^{-1} + 100 % RDFrecorded the lowest root length of 10.01 cm, root girth of 3.80 cm, root weight per plant 60.03 g, root yield per plot 10.80 kg, root yield 7.14 t ha^{-1}.

Table 3: Effect of intercropping and fertilizer doses on yield characters of radish intercropped with tomato

Characters	Pure crop (100 % RDF)	Intercrop		
		Tomato with 100 % RDF + Radish	Tomato with 125 % RDF + Radish	Tomato with 150 % RDF + Radish
Root length (cm)	11.40	10.01	10.49	11.05
Root diameter (cm)	4.14	3.80	3.92	4.08
Root weight / plant (g)	80.05	60.03	72.0	77.0
Root yield / plot (kg)	46.39	10.80	12.59	13.76
Root yield (t ha^{-1})	30.68	7.14	8.33	9.10

Table 4: Effect of intercropping and fertilizer doses on yield characters of small onion intercropped with tomato

Characters	Pure crop (100 % RDF)	Intercrop		
		Tomato with 100 % RDF + Small Onion	Tomato with 125 % RDF + Small Onion	Tomato with 150 % RDF + Small Onion
Bulb length (cm)	4.31	2.89	3.03	3.53
Bulb diameter (cm)	4.25	2.91	3.36	3.75
Bulbs / plant	7.75	5.45	6.35	6.97
Individual bulb weight (g)	6.81	5.24	5.82	6.29
Bulb yield / plant (g)	52.17	28.36	36.77	44.84
Bulb yield / plot (kg)	26.25	6.32	7.75	9.12
Bulb yield (t ha^{-1})	17.36	4.18	5.13	6.04

Yield attributes and yield of small onion

The observation recorded on yield attributes and yield of small onion are presented in Table 4.The maximum bulb length (4.31 cm), bulb diameter (4.25 cm), number of bulbs per plant (7.75), individual bulb weight (6.81g), bulb yield per plant (52.17g), bulb yield per plot (26.25 kg), bulb yield per hectare (17.36 t ha^{-1}) were recorded in sole stand of small onion. Growing of small onion within tomato inter rows along with application of 25 t FYM ha^{-1} + 150 % RDFproduced more bulb length of 3.53 cm, bulb diameter of 3.75 cm, number of bulbs per plant of 6.97, individual bulb weight of 6.29 g, bulb yield per plant of 44.84 g, bulb yield per plot of 9.12 kg, bulb yield per hectare of 6.04 t over other intercropping treatments. Whereas, small onion raised with tomato under intercropping system along with the application of 25 t FYM ha^{-1} + 100 % RDFrecorded the minimum bulb length (2.89 cm), bulb diameter (2.91 cm), number of bulbs per plant (5.45), individual bulb weight (5.24 g), bulb yield per plant (28.36 g), bulb yield per plot (6.32 kg) and bulb yield per hectare (4.18 t).

Yields attributes and yield of vegetable cowpea

The data recorded on yield attributes and yield of vegetable cowpea are presented in Table 5. The maximum values of pod length (21.57 cm), pod diameter (0.75 cm), number of pods per plant (16.95), individual pod weight (5.05 g), pod yield per plant (62.04 g), pod yield per plot (11.45 kg) and pod yield per hectare (7.57 t) were recorded in sole stand of vegetable cowpea. Vegetable cowpea grown within tomato inter rows along with application of 25 t FYM ha^{-1} + 150 % RDFproduced higher pod length of 18.39 cm, pod diameter of 0.66 cm, number of pods per plant (15.46), individual pod weight of 4.60 g, pod yield per plant of 51.65 g, pod yield per plot of 3.92 kg and pod yield of 2.59 t ha^{-1}over other intercropped treatments.

Table 5: Effect of intercropping and fertilizer doses on yield characters of vegetable cowpea intercropped with tomato

Characters	Pure crop (100 % RDF)	Intercrop		
		Tomato with 100 % RDF + Vegetable Cowpea	Tomato with 125 % RDF + Vegetable Cowpea	Tomato with 150 % RDF + Vegetable Cowpea
Pod length (cm)	21.57	15.13	16.53	18.39
Pod diameter (cm)	0.75	0.53	0.59	0.66
No. of pods / plant	16.95	12.35	14.16	15.46
Individual pod weight (g)	5.05	3.73	4.15	4.60
Pod yield / plant (g)	62.04	32.15	41.73	51.65
Pod yield / plot (kg)	11.45	2.60	3.27	3.92
Pod yield (t ha^{-1})	7.57	1.72	2.16	2.59

Intercropping vegetable cowpea in tomato along with the application of 25 t FYM ha^{-1} + 100 % RDFhad recorded the lowest pod length (15.13 cm), pod diameter (0.53 cm), number of pods per plant (12.35), individual pod weight (3.73 g), pod yield per plant (32.15 g), pod yield per plot (2.60 kg) and pod yield per hectare (1.72 t).The yield attributes of various component crops namely radish, small onion, vegetable cowpea were considerably influenced by intercropping system, but sole stand of component crops recorded higher yield attributes than the intercropping system. This was due to the lesser competition for nutrients and sunlight in solid stand where the optimum population was maintained. This clearly brings out the competitive effect of base crop on the growth and development of intercrops.

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