STUDY ON EFFECT OF SOYBEAN AND TEA INTERCROPPING ON YIELD AND YIELD COMPONENTS OF SOYBEAN AND TEA

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ABSTRACT

The factorial experiment (2×2×3) was done over five years to survey the best planting and density patterns of two cultivars of soybean in a cleanly pruned tea plantation. The effects of these three factors were studied on soybean and tea yield and yield ingredients. The first factor (i.e., soybean cultivars) was distributed in two levels including Williams and Williams Chipava cultivars, as well as second factor (i.e., planting pattern) was doled out in two levels including single and double row planting. The third factor (density of planting) contained 12, 17 and 22 plants per m^{-2}. The results showed that planting pattern and interaction of "cultivar × density" had significant effect ($p<0.01$) on soybean yield. Based on mean comparison, maximum yield of soybean was obtained under single-row planting. On the other hand, single-row planting of "Williams Chipava" cultivar with 22 plants m^{-2} had the highest yield. While Williams's cultivar produced minimum yield by 12 and 22 plants m^{-2}, respectively. Planting pattern resulted in tea yield rising ($p<0.01$). The highest tea yield gained by double-row soybean planting.

Keywords: tea, soybean, clean pruning, density, planting pattern.

INTRODUCTION

Beneficial life duration of tea bushes is about 60 years. The hundred-year-old bushes of Iran's tea plantations caused reduction of economic yield (Janatpoor, 2004). For avoidance of yield decrease, heavy pruning of tea is imperative for juvenescence of bushes. Heavily pruned tea plantation rows are empty of vegetation. There are some problems in pruned tea fields with bush recovery time, including possibility of soil erosion, weed growth and competition with tea bushes and loss of soil moisture. In addition, there is, most importantly, the decrease in farmers' income because of lack of plucking (Janatpoor, 2004). Therefore, choosing a proper plant seems useful for planting between pruned tea rows. Soybean is cultivated increasingly due to genetic diversity and broad compatibility in a wide range of geographic latitudes and is the production leader among oil seeds plants (Board and Hall, 1984).

Light energy efficiency in photosynthesis depends on the plant density and transition of light to plant canopy (Edwards *et al*., 2005; Boquet 1990). Increasing the number of plants per area causes decrease of yield due to canopy shading and, hence, lessens single-plant yield (Boquet, 1990). Edwards *et al*. (2005) revealed that plant maturity and plant population interact to affect cumulative intercepted photosynthetically active radiation (CIPAR) and that, without water and nutritional limits, CIPAR determines soybean yield. These relationships were used to find out a mechanistic model describing the response of soybean biomass and yield to plant population. Wells (1993) reported that plant spacing affects leaf area, light interception, and canopy apparent photosynthesis in soybean. Boquet (1990) found limited light interception in high plant population density causes increasing height and decreasing fertile nodes. Ranjbar *et al*. (1987) reported that the best efficiency of vegetation can be gained by minimum intraspecies and interspecies competition to light interception. Nowadays, intercropping is utilized extensively in tropical areas. Some advantages of intercropping are efficient use of environmental resources, proper exchange of nutrition, reduced weeds and pathogens damage and increasing soil fertility (Javanshir *et al*., 1999; Mazaheri, 1994).

Proper crop choice is important to succeed in tea intercropping. Intercropping of some plants with tea is common in different tea producing nations. Accordingly, Albizia tree is planted in tea plantations in India and China. Since tea bushes are shade tolerant plants, shade trees are used to change microclimates of tea plantations. In some of Iran's tea plantations, farmers are planting traditionally different crops including corn, beans, soybean, peanut and sorghum (Janatpoor, 2004). Janatpoor (2004) found that soybean intercropping in heavily pruned tea plantations can cause expansion of tea-plant surface, increase tea yield, control weeds and create income for farmers.

But, the most important factor in tea intercropping is tea quality. Many factors affect the quality of black tea, including, cultivar, plucking manner, processing and storage of tea (Hojat-ansari *et al*., 2008). Yunusa (1989) found that soybean and maize yields in strip cropping was more extensive than irregular intercropping.

Tang (1998) revealed that tea bushes grow suitably under the canopy of shade trees. Appropriate canopy trees can increase yield and quality of tea. Jianhui and Rungnan (1998) reported planting fruit or timber trees in tea plantations caused increased photosynthesis rate, dry matter and caffeine of tea leaves. The aim of this study was to determine suitable planting patterns of soybean cultivars in tea plantations.

MATERIALS AND METHODS

The experiment was carried out at the Research station of Kashef, Ezberam, Siahkal (lat 37°14′N, long 49°93′E) in the Guilan province of Iran, in the period 2004-2008. 12 treatments were arranged as factorial experiments with randomized complete block design in three replications. Three trial factors were:

Factor A: soybean cultivars at two levels (including; Williams and Williams Chipava line)

Factor B: soybean planting pattern at two levels (including; one and two planting row)

Factor C: plant density at three levels (including; 12, 17 and 22 plant m^{-2})

This trial was conducted in land of area 1100 m^2 with tea clone named 100. The soil of experimental plots was a sandy clay loam. Each plot consisted of five tea bush rows (45 × 90cm bush and row spacing) wide by approximately 4.8m long. Clean pruning of tea bushes was operated on February 2004 and soybean cultivation was performed on May 21, 2005. During the growth season, the desired characteristics of soybean and tea bushes were noted.

Eight soybean plants were harvested at maturity from each plot for measuring plant height, number of branches of each plant and yield components such as number of pods per plant, number of seeds per plant and seed yield. Seed protein and oil were determined by weighing 150 g samples in each treatment and using Kjeldahl method. The tea leaves yield was evaluated several months after tipping (light pruning). Tea plucking was carried out according to the tea plantation regional routine during other experimental years. Frame formation pruning was performed after plucking season in winter, 2006. Materials obtained from frame pruning were weighed. Also, evaluation of qualitative traits of tea was conducted in the last year (2008). Some qualitative traits of tea including aqueous extract, tannins percent (Smiechowska and Dmowski, 2006) and theaflavins and thearubigins content (Mahanta and Baruah, 1992) were measured. Analysis of variance and mean comparison based on the Duncan method were carried out using MSTATC.

RESULTS AND DISCUSSIONS

Soybean traits

Soybean yield

Analysis of variance (Table-1) showed that effects of cultivar (factor A) and plant density (factor B) were not significant on soybean yield. But, the planting pattern (factor C) have had significant effect on the soybean yield ($p<0.01$). Among interaction effects, just "cultivar × plant density" changed, significantly, soybean yield ($p<0.01$).

Table-1. ANOVA table based on all factors and interactions (soybean traits).

Source	df	Mean square						
		Soy yield	**Protein (%)**	**Oil (%)**	**Pod no.**	**Seed/ pod**	**Soy height**	**Side branches no.**
Replication	2	252181^{ns}	2.06 ^{ns}	0.12 ^{ns}	659.8**	0.02 ^{ns}	148 **	1.4 **
Cultivars (A)	1	401322 ^{ns}	0.6 ^{ns}	1.2 ^{ns}	7.6 ^{ns}	1.5 **	793.4 **	0/1 ^{ns}
Planting pattern (B)	1	208658 **	0.7 ^{ns}	0.004 ^{ns}	2557**	0.1 ^{ns}	1167 **	3/3 **
A× B	1	20496 ^{ns}	0.3 ^{ns}	0.2 ^{ns}	0.04 ^{ns}	0.001 ^{ns}	0.03 ^{ns}	0/3 ^{ns}
Planting density (C)	2	2.9 ^{ns}	2.6 ^{ns}	0.7 ^{ns}	1.9 ^{ns}	0.2 ^{ns}	10.2 ^{ns}	0/4 ^{ns}
A×C	2	159075 **	0.9 ^{ns}	1.8 ^{ns}	27.9 ^{ns}	0.1 ^{ns}	3880 **	0/3 ^{ns}
B × C	2	5.6 ^{ns}	0.6 ^{ns}	1.5 ^{ns}	0.165 ^{ns}	0.09 ^{ns}	0.5 ^{ns}	0/1 ^{ns}
A × B × C	2	85020 ^{ns}	1.2 ^{ns}	1.03 ^{ns}	0.412 ^{ns}	0.2 ^{ns}	2.2 ^{ns}	1/4 **
Error	22	214128	1.01	0.7	11.2	0.231	11.9	0/1
CV (%)	-	22.9	2.6	3.8	4.7	20.2	2.7	14.6

**: significant difference at 1%, *: significant difference at 5%, ns: non significant difference.

Single-row soybean planting between tea rows caused further yield than double-row planting (Table-1 and Figure-1). Soybean yield under single-row planting was 2263 kg/ha, while this quantity was 1781kg/ha under double-row planting. Therefore, the yield of soybean under single-row planting was about 20% more than double-row planting. Maximum soybean yield was gained by Williams Chipava with 22plant m^{-2} and also the lowest yield belonged to Williams with 12 plant m^{-2} (Table-2). This yield difference is over 27% (Figure-2). Two evaluated cultivar had significant difference in yield under treatment 17 plant m^{-2}, so Williams produced the utmost yield in this planting pattern, but Williams Chipava had lowest yield in this pattern (Table-2). Caliskan *et al.*

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(2007) found that substantial yield increase by decreasing row width from 70 to 50 cm, and no increase on seed yield by further decreasing the row width in full season soybeans. In double cropping, however, yield increased significantly by decreasing the row width from 70 to 50 cm and from 50 to 30 cm. They reported that optimizing plant density, by adjusting row spacing to increase light interception, is the most feasible practice for double-cropped soybean.

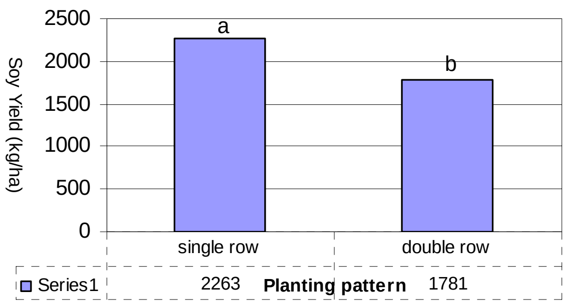

Figure-1. Soybean yield under single and double planting.

Table-2. Data mean comparison of "cultivar × planting density" interaction on height and yield of soy.

Cultivar	Density (plant/m^2)	Soy height (cm)	Soy yield (kg/ha)
Williams	12	111 b	1706 b
	17	112.7 b	2337 a
	22	141 a	1706 b
Williams Chipava	12	109 b	2337 a
	17	140 a	1708 b
	22	144 a	2338 a

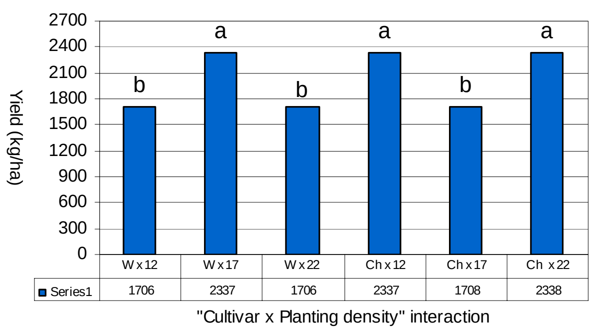

Figure-2. Cultivar and plant population density interaction effect on soybean yield. (W = Williams, Ch = Chipava and 12, 17 and 22 shows plant number per square meter)

In the present study, double-row planting pattern caused decrease seed number per plant due to increased competition in high densities. But, seed yield not only did not decrease, but also it increased. When plants are widely spaced, dry matter production will at first tend to increase linearly with increase in plant density due to no or minimum competition between the adjoining plants.

Further increase in density may lessen the dry matter production, probably because of competition between plants, and the yield of the individual plants may get reduced. However, this is compensated by the increase in the number of plants per unit area. Any further increase in plant density results in a plateau of practically constant dry matter production. This shows that an equilibrium has been reached at which the increase in production due to increased plant number compensates the decline in the production of the individual plants. An ideal number of plants are needed per unit area to utilize efficiently the available environmental factors (Duncan 1986). Boquet (1998) found that planting date and cultivar selection were the most important factors for increasing yield, while row spacing was less significant.

Parvez *et al.* (1989) revealed that node and pod numbers, leaf area index (LAI), crop growth rate, total biomass and seed yields were significantly increased with increasing plant population density (PPD) up to a certain PPD, depending on spatial arrangement. Lueschen and Hicks (1977) found plant height and maturity were not affected by plant population while lodging was increased at higher plant densities. The height above the soil surface of the lowest pod-bearing node increased as plant density was increased. Numbers of branches, pods, and seeds per plant decreased as population increased. Their results marked that soybeans have the ability to compensate for a wide range of plant densities without affecting yield. Pamela and Weaver (1998) also reported that yield increased when plant population increased. Several researchers (Khajehpour, 1987; Boerma and Ashley, 1982; Boquet, 1990; Cordonnier and Johnston, 1983; Duncan, 1986) reported that maximum seed yield is obtained under high plant densities.

Protein and oil of soybean seed

Analysis of variance (Table-1) showed that any evaluated factors and their interactions did not significantly affect protein and oil of seed. These soybean traits seem constant in an intercropped system. Importantly, oil and soy protein are influenced by genetic factors but environmental and agricultural factors do not affect them. Purhago (2008) reported that different plant densities and cultivar did not significantly affect soybean oil and protein.

Pod number

Table-1 shows that cultivar and plant population densities had no significant effect on the number of pods per plant. But, the planting pattern affected this feature significantly ($p<0.01$). Based on data mean comparison (Table-3), the highest number of pods (79 pod plant^{-1}) belonged to a single-row planting pattern. Whilst the minimum number of pods (62 pod plant^{-1}) was obtained under double-row planting. Increased plant populations decrease the number of side branches (Pawlowski *et al.*, 1993; Ibrahim and Hala, 2007; Caliskan *et al.*, 2007), pod number per plant, seed yield per plant (Shafshak *et al.*, 1989; Pawlowski *et al*., 1993), 100 seed weight (Pawlowski *et al*., 1993), harvest index (Spaeth *et al*., 1984). While yield components such as first pod height (Pawlowski *et al*. 1993) and seed yield per hectare (Caliskan *et al*. 2007) were increased. Pod number affected seed yield. Number of pods plant^{-1} is a more unsteady attribute among yield components of legumes. Legumes' potential in the floral buds, flowers and pods formation is too high, but to achieve ideal potential, proper environmental and internal plant conditions should be available (Kocheki and Banayan Aval, 1994). Khademhamze *et al*. (2004) reported the number of pods plant^{-1} declines with rising plant density.

Table-3. Data mean comparison of planting pattern on some traits of soy and tea plants (DMRT 5%).

Planting pattern	**Pod no.**	**Soy height** (cm)	**Total tea yield** (kg/ha)	**Tea pruning residue** (kg/bush)	**Tannins %** (spring tea)	**Water extract %** (spring tea)
Single row	79.4 a	120 b	23258 b	1.9 b	13 b	40.9 b
Double row	62.6 b	132 a	28555 a	2.4 a	13.4 a	41.3 a

Parvez *et al*. (1989) reported that increased plant density lessens the number of pods plant^{-1}, but in general the node number unit area increases. In high densities, because of increased competition for light and nutrients, the number of nodes and fertile flowers is reduced. On the other hand, by increasing the number of plants per unit area, space and nutrients will be reduced for each plant. Therefore, plant growth and number of side branches significantly reduces and, finally, pod number decreases (Boquet, 1990). But, competition between plants decreased with lower plant density and, thus, more side branches per plant produce and increase the number of pods plant^{-1} (Kocheki and Sarmadnia, 2001).

Seed number in pods

Based on ANOVA (Table-1), the effect of cultivar was significant on seed number per pod ($p<0.01$). The planting pattern and plant population density had no significant effect on seed number. Williams produced the highest seed number per pod. Number of seeds per pod is the steadiest yield component of Leguminosae (Kocheki and Banayan Aval, 1994). Hansen and Shibles (1978) reported number of seeds per pod, influences by genetic structure and agricultural/environmental factors have little effect on this attribute.

Plant height

The results (Table-1) showed the cultivar, planting pattern and interaction of “cultivar × plant density” affected, significantly, the height of soy ($p<0.01$). The comparison data (Table-2) also showed both Williams and Williams Chipava cultivars produced the highest and lowest plant height under plant population density 22 and 12, respectively. A similar result was also reported by Hoggard *et al*. (1978). In both cultivars, when plant density is too high, it encourages interplant competition for resources. Then, plant height will be affected by less light penetration in the crop canopy as well as increase in the competition for available nutrient which will affect plant branches. The plants which received less light increased the height of the main stem to compensate for this deficiency and to achieve more radiation. Ganjali and Majidi (2000) and Cho *et al*. (2004) also reported similar results, and they noted that plant height is increased under too high plant density due to competition for light interception. The results indicated that soybean height was affected genetically (cultivar) and environmentally (plant population density).

Number of branches

With respect to simple effects of cultivar and plant population density these bore no significance on the number of branches, but, planting pattern affected this trait significantly ($p<0.01$). Trilateral interaction of "cultivar × planting pattern × plant density" influenced, significantly, the number of branches (Table-1). Data mean comparison (Table-4) showed that cultivar Williams Chipava under single-row planting and density 17 plant m^{-2} produced the highest number of branches (3.3 branches plant^{-1}). While cultivar Williams could produce 3.3 branches plant^{-1} under single-row planting with 12 plant m^{-2}. The number of lateral branches was decreased by double-row planting pattern. Pamela and Weaver (1998) stated that increased plant populations decrease number of side branches. Majnoun Hosseini *et al*. (2001) reported that soybean yield components such as numbers of branches, pods, and seeds per plant decreased linearly as population density increased.

VOL. 7, NO. 9, SEPTEMBER 2012 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

Table-4. Trilateral interaction of "cultivar × planting pattern × plant density" on soy and tea traits.

cultivar	planting pattern	(plant/m^2)	Soy side branches no.	Tea traits		
				Shoot no.	Height (cm)	Autumn's tannin (%)
Williams	Single row	12	3.3 a	20 c	80.7 ab	12.8 a
		17	2.7 abc	21.33 bc	81.33 ab	11.69 b
		22	2.6 abc	20.33 c	81.33 ab	12.8 a
	Single row	12	2.33 bcd	25.7 a	77.7 b	12.4 ab
		17	2.1 cd	21 c	77.7 b	12.43 ab
		22	1.7 d	25.33 ab	84.33 a	12.47 ab
Williams Chipava	Double row	12	2.33 bcd	22.7 abc	81.7 ab	11.53 b
		17	3.33 a	21.33 bc	81 ab	12.97 a
		22	2.67 abc	22.33 abc	81.33 ab	11.98 ab
	Double row	12	3 ab	21.67 abc	78.33 b	12.51 ab
		17	2.06 cd	21 c	84.7 a	12.36 ab
		22	2 cd	25.33 ab	85 a	12.06 ab

Tea plant traits

Total tea yield

ANOVA of tea traits (Table-5) showed that soybean planting pattern affected, significantly, the cumulative yield of tea leaves (over four years) ($p<0.01$). But, the simple effects of cultivars and plant population density as well as trilateral effect of "cultivar × planting pattern × plant density" and other interaction effects of treatments were not significant on the tea yield.

The highest yield of tea (28555 kg/4 years) was obtained by soy double-planting pattern, and the lowest yield (23258 kg/4 years) was produced by single-row planting (Table-3). Cumulative yield of tea in double-row planting was compared with control using T-test. Results revealed that tea yield of control plots (23868 kg/4 years) was less than double-row planting one. But, differences of tea yield in control and single-row planting plots were not significant. Sedaghathoor (1999) stated, that in addition climate conditions, several factors such as agricultural operations, plant age, dry period, different seasons, different methods of plucking and soil minerals availability have significant impacts on yield of tea.

Table-5. ANOVA table based on all factors and interactions (tea traits).

Source	df	Mean square							
		Tea total yield	Shoot no.	Height (cm)	Expanded surface	Pruning residue	Spring's tannin	Autumn tannin	Spring's aqueous extract
Replication	2	47933267^{ns}	18.7^{*}	48.8^{**}	0.001^{ns}	1.1^{*}	0.07^{ns}	0.3^{ns}	0.7^{ns}
Cultivars (A)	1	2921820^{ns}	0.1^{ns}	23.4^{ns}	0.002^{ns}	0.4^{ns}	0.1^{ns}	0.3^{ns}	1.07^{ns}
Planting pattern (B)	1	252502693^{**}	36^{**}	0.03^{ns}	0.001^{ns}	0.9^{**}	0.9^{*}	0.05^{ns}	1.8^{*}
A× B	1	9112348^{ns}	18^{ns}	14.7^{ns}	0.007^{ns}	0.6^{ns}	0.1^{ns}	0.05^{ns}	0.07^{ns}
Planting density (C)	2	5730691^{ns}	0.25^{ns}	0.03^{ns}	0.004^{ns}	0.3^{ns}	0.05^{ns}	0.008^{ns}	0.4^{ns}
A×C	2	11351350^{ns}	9.7^{ns}	48.03^{**}	0.002^{ns}	0.3^{ns}	0.02^{ns}	1.4^{**}	0.1^{ns}
B × C	2	16534452^{ns}	0.25^{ns}	0.03^{ns}	0.002^{ns}	0.3^{ns}	0.02^{ns}	0.1^{ns}	0.09^{ns}
A × B × C	2	28520998^{ns}	29.4^{**}	35.03^{**}	0.002^{ns}	0.4^{ns}	0.5^{ns}	1.4^{**}	0.7^{ns}
Error	22	27463701	4.9	5.9	0.002	0.3	0.2	0.3	0.4
CV (%)	-	20.2	9.9	3	13.1	22.8	3.5	4.2	1.5

**: significant difference at 1%, *: significant difference at 5%, ns: non significant difference.

Tea shoots number

Analysis of variance (Table-5) showed that planting pattern and trilateral interaction of experimental factors influenced, significantly, shoots number of tea (the first year after pruning) ($p<0.01$). The highest number of tea shoots (25.7 shoots bush^{-1}) was obtained under interaction "Williams's cultivar × double-row planting × 12 plants m^{-2}". While the lowest number of shoots (20 shoots bush^{-1}) was produced in single-row planting of Williams with 12 plant m^{-2} (Table-4). Size of harvested shoots is a significant factor of tea yield. Additionally, weight of plucked shoots and number of produced shoots per unit area depend on the growth rate and the average weight of shoots (Sedaghathoor, 1999).

Tea height

Based on results (Table-5), any simple effect of experimental factors (soy cultivar, planting density and planting pattern) was not significant on the height of tea bushes in the first year after pruning. But, interaction effect of "cultivar × plant density" and trilateral effect of studied factors caused significant difference on the height of tea bushes ($p<0.01$). Data mean comparison (Table-4) showed that "Williams Chipava cultivar × double-row planting × 22plant m^{-2}" caused the highest tea-plant height (85 cm).

Expanded surface of tea bushes

Analysis of variance (Table-5) showed that this characteristic of tea-plant does not influence by intercropping. It seems the expanded surface of tea depends on different pruning processes which act on tea bushes yearly.

Cut across pruning residues

As in the implementation of pruning cycle, the cut across pruning carried out second year after clean pruning. This pruning residue was evaluated. Data Analysis in 2006 showed that effect of the soy planting pattern was significant on the pruning of tea plants residues ($p<0.05$).

Mean comparison (Table-3) showed the highest pruning a residue was obtained under double-row soy planting (2.4 kg/bush). The least amount of pruning residues (1.97 kg/bush) was also obtained under single-row planting. It seems that larger amount of pruning residues depends on increased growth of tea bushes due to soil fertility with increased soybean plants organic matters in double-row planting. Jianhui and Rungnan (1998) reported the intercropping of fruit trees with tea caused increased photosynthesis and dry matter production of tea.

Tannins

Data analysis of variance in the spring of 2008 (Table-5) showed that the simple effect of cultivar and density of planting were not significant on tannin content in tea. But, the planting pattern significantly changed tannin content in springtime ($p<0.01$). Trilateral effect of "cultivar × planting pattern × plant density" had no significant effect on this attribute. Data mean comparison (Table-3) showed the highest tannin content (13.4%) was obtained under double row planting pattern. The minimum amount of tannin was gained in single row planting. All single treatments had no significant effect on tannin content of summertime tea. While planting pattern was alone single treatment which affected significantly autumnal tea tannin. Trilateral effect of experimental factors was significant on Autumnal tea tannin. Data mean comparison data (Table-4) showed the highest percentage of tannin was produced under single-row planting of "Williams Chipava" with 17 plants m^{-2}.

The lowest tannin belonged to "Williams Chipava" with 12 plants m^{-2}. The most important polyphenol of tea beverage is tannin or Gallic acid. Gallic acid is a phenolic acid which affects on appearance and quality of tea beverage (Hara *et al*. 1995). According to Sheibani (1991) tannin content correlated with soil type and harvesting hours in a day and in different seasons.

Aqueous extract

Analysis of variance (Table-5) showed the cultivar and planting density factors had no significant effect on the amount of aqueous extract of tea in the spring of 2008. But pattern of cultivation influenced aqueous extract of tea ($p< 0.05$). The interaction of three experimental factors did not show any significant effect. The highest amount of aqueous extract of tea (41.35%) was obtained under double row cultivation of soybean (Table-3). The minimum amount of aqueous extract of tea (40.9%) was acquired under single row cultivation pattern. Based on results (Table-3), none of the factors and their interactions influenced, significantly, summer and autumn aqueous extract of tea.

Theaflavin (TF)

Results showed that planting density and "planting density × cultivar" interaction were affected TF in summertime tea, significantly (Table-6). Other factors and their interaction had no effect on TF in summertime tea. ANOVA (Table-6) showed none of the factors and their interactions did significantly influence Autumnal TF. Single row planting pattern with 12 and 17 soy/m^2 caused production of minimum TF (0.44%) and maximum TF (0.55%), respectively, in summertime tea. On the other hand, T-test showed no significant difference between single row planting pattern with 12 soy/m^2 and control (tea rows without soy planting).

Table-6. ANOVA table based on tea traits including; Theaflavin (TF) and Thearubigin (TR).

Source	df	Mean square			
		Summer TF	**Autumn TF**	**Summer TR**	**Autumn TR**
Replication	2	0.003 ns	0.006 ns	3.49 ns	2.32 ns
Cultivars (A)	1	0.005 ns	0.006 ns	0.6 ns	1.71 ns
Planting pattern (B)	1	0.000 ns	0.000 ns	0.46 ns	0.20 ns
A× B	1	0.001 ns	0.004 ns	11.24**	0.004 ns
Planting density (C)	2	0.007 *	0.000 ns	0.04 ns	0.000 ns
A×C	2	0.002 ns	0.007 ns	0.95 ns	1.72 ns
B × C	2	0.013 **	0.000 ns	0.37 ns	0.812 ns
A × B × C	2	0.001 ns	0.017 ns	0.23 ns	5.13 ns
Error	22	0.002	0.007	0.62	3.47
CV (%)	-	8.79	15.68	5.71	13.64

**: significant difference at 1%, *: significant difference at 5%, ns: non significant difference.

Thearubigin (TR)

Analysis of variance (Table-6) showed that only the interaction "cultivar × planting pattern" has affected TR, significantly, in summertime tea. While none of the factors and their interactions did significantly affect TR in autumn tea. Data mean comparison showed that single row planting of Williams's cultivar caused the highest TR (14.41%). It seems that the amount of TR and TF/TR ratio is not affected by intercropping. Tea value depends on the amount of tannin in tea and its change is not correlated to different parts of tea plant. But, tannins are influenced by season, soil type and during harvesting time (Sedaghathoor, 1999). Finally, we can say that intercropping of some annual plant such as soybean in tea plantation can help growers, economically.

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