Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.19, 2015 www.iiste.org

Effect of Temporary Shade Tree Species on Growth Performance of Newly Transplanted Arabica Coffee Seedlings at Jimma

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Abstract
A field experiment was conducted at Jimma Agricultural Research Centre (JARC) with an objective to investigate the effect of various temporary shade tree species on survival rate, early growth performance and field establishment of Arabica coffee seedlings between 2008 and 2014 cropping season. A randomized complete block design (RCBD) with three replications was used. The treatment consisted of temporary shade tree species *vis*. Pigeon pea (*Cajanus Cajan (L.) Millsp)Tephrosia sp.* Caster bean,*Leucaena sp., Sesbania sesbane,* grass hat (''Gojo'') and open plot as a control. Coffee seedlings were raised using a CBD resistant coffee cultivar, 74110 following the recommended nursery management practices. Each experimental plot constituted of 12 coffee seedlings planted at 2m by 2m spacing. Seeds of pigeon pea,*Tephrosia*, Caster bean,*Luecnea* and *Sesbania sesbane*which were collected and prepared have been sown between coffee rows in east and west directions so as to protect seedlings from morning and afternoon sun injury. Significant ($P \leq 0.05$) variations were detected among treatments for nearly all growth parameters studied. Accordingly, almost all distractive and non-distractive growth parameters were considerably affected by temporary shade treatment. In general grass hat treatment followed by Sesbania sesban showed best growth performance of coffee seedlings. Thus areas with ample rainfall or soil moisture Sesbania sesban and Pigeon pea can be used as temporary shade for coffee seedlings if planted under wider spacing (4 m x 4 m) sesbania sesban and (2 m x 2 m) pigeon pea so as to reduce their competition effect with young coffee tree for climatic and soil resources.
Keywords: - inter row, intra row, temporary shade tree and transplanted seedlings

Introduction

Ethiopia is center of origin and genetic diversity for coffee (*Coffea arabica L*). Arabica coffee was found growing naturally within indigenous shade tree species in southwestern part of the county.The management of shade is, however, quite variable ranging from heavy dense shade to relatively low or absent. It was reported that the risk of soil erosion and over bearing dieback tremendously increased in a production system of having fewer or absent shade trees. This condition is also favorable for the infestation of perennial noxious weeds (Workafes and Kassu, 2000).

Coffee is a shade loving plant that traditionally grows as understory crop in its center of origin Arabica coffee has been found growing naturally under the shade of various tree species in the southwestern Ethiopia. It is also a common practice now to plant coffee seedlings first under temporary and later under permanent shade trees (Demel and Assefa, 1991). The author further indicated those indigenous shade tree species *viz. Albizia gummifera, Allophylus abyssinica, Celtis Africana, Cordia africana, Millitia ferrugenea* and *Croton mycrostachys* are among a wild forest species maintained by coffee growers. Scientists seem to agree that the best way to preserve Arabica coffee is through the use of shade trees (Ramirez-Villegas *et al*., 2012). Shade trees planted near coffee plants have the ability to block out the sun's impact on the plants. They create lower temperatures better suited for Arabica coffee plants. According to Jaramillo *et al*. (2011) shade trees can cause a reduction in temperature by up to 4 degrees Celsius.

The extent, type and use of shade trees employed in a shaded perennial cropping system vary from farm to farm and region to region. According to Demel and Assefa (1991), farmers of seven Hararghe provinceshave chosen shade trees on the basis of trees ability to ameliorate soil fertility and feed stuff provision to their livestock. On the other hand, some farmers at Gera and Goma areas of Jimma zone have greater preferences for trees yielding better coffee harvest and quality (unpublished Survey Data). Demel (1990) has also stated that shade trees selection in some coffee producing areas of Ethiopia is highly influenced by ease of propagation techniques.

Many authors have agreed that shade trees offer several advantages to coffee plant. These may include provision of organic matter to improve soil fertility up on litter fall decomposition (Beer et al., 1997). Apart from their obvious role as sun screen and nutrients source, the presence of litter fall is also useful in soil moisture conservation and suppression of growth ofnoxious grassy weeds (Palm, 1995). Yacob et al. (1996) summarized that the aforementioned merits are quite important to improve the productivity (yield and quality) of coffee in Ethiopia. It is because shaded coffee farm are, in most cases, recognized as organic, sustainable and less costly if trees selection is made in due care (Herzog, 1994; Kimemia, 1997).

Research findings indicated that legume shade trees are more efficient in transferring N, P, K, Ca and Mg to the soil as compared to non-legume which in turn affects the amount and type of nutrients taken by associated crops (Fassbender, 1987). Besides coffee processing and breeding activities, variations in nutrient up-take reflected by differences in coffee quality (Babbar and Zak, 1994). For instance, the qualities of raw coffee bean, roast, acid liquor and flavor were significantly lowered if certain maximum and minimum levels of K and Ca in the raw beans (Northmore, 1965). Njoroge (1993) also confirmed that coffee nurtured beanth the canopy of shade trees tend to produce beans with varying element content and quality as well.

Furthermore temporary shade at time ofearly field transplanting is very decisive for better growth and field survival of coffee seedlings. So far artificial shade that is construction of grass hat ('Gojo') in east and west direction of coffee seedling was traditionally used however it is very expensive. However study conducted in Indiaand Brazilindicated that temporary shade tree species can be used for early shade provision to coffee seedlingsuntil initial two to three crop seasons i.e., till the permanent shade tree canopy cast shade to young coffee trees. Therefore the objective of the study was to investigate the effects of temporary shade tree species on growth performance of coffee seedlings, weed smothering effect and soil fertility enrichment in southwester Ethiopia.

Materials and Methods

The study was conducted in south-western Ethiopia, at Jimma Agricultural Research Centre (JARC) geographically located 7° 7' N and 36° E. It is situated within the Tepid to cool humid highlands agro-ecological zone of the country at an altitude of 1750 meters above sea level. The site receives high amount of rainfall with a long-term mean total of 1573.6 mm per annum, which is distributed into 166 days. The driest months usually last between November and February.The mean maximum and minimum air temperatures are 26.3 and 11.6 °C, respectively(JARC, 2014) should be appeared on the reference.

The experiment wascarried out with an objective to investigate the effect of various temporary shade tree species on survival rate, early growth performance and field establishment of Arabica coffee seedlings at JimmaAgricultural Research Center (JARC). A randomized complete block design(RCBD) with three replications was used. The treatment consisted of temporary shade tree species *vis*. Pigeon pea (*Cajanus Cajan (L.) Millsp.*)*Tephrosia sp.*Caster bean(*Ricinus commonus*),*Leucaena sp., Sesbania sesbane,* grass hat (''Gojo'') and open plot as a control. Coffee seedlings were raised using a CBD resistant coffee cultivar,74110 following the recommended nursery management practices (Anteneh, 2008). Each experimental plot constitutedof 12 coffee seedlings planted at 2 m by 2 m spacing. Seeds of pigeon pea,*tephrosia*, caster bean,leucaenaandsesbania which were collected and prepared have been sown between coffee rows in east and west directions so as to protect seedlings from morning and afternoon sun injury. Each temporary shade tree species was sown 1m away from the coffee seedlings. However the intra-row spacings used were20, 40, 400, 100 and 20cm for pigeon pea, tephrosia, sesbania, castor beanand leucaena,respectively. In addition, the conventional grass hat or "*Gojo*" plotwasincluded by constructing it in anupright position by the side of east and west direction for each coffee seedling as a control plot. Except the experimental variable all other field management practices were applied according to the recommendation (Endale*, et al*., 2008). Data on survival rate of coffee seedlings, distractive and non-distractive growth parameters of coffee seedlings were recorded in each round of the experiment. One composite soil sample was collected from experimental field at depth of 10, 20, and 30 cm during the inception of the experiment. Besides coffee leaf samples were collected every year until the completion of the study based on the recommendation of Bould *et al.* (1971). The collected soil and leaf sample was analyzed for N, P, K, Ca and Mg using the appropriate procedure.

Major weeds, weed density and biomass and frequency of weeding was recorded. Weed biomass was recorded using a 1m by 1m quadrant placed on each plot right before weeding. Besides cost of weeding was recorded.Amount of light intercepted (%) and Costs: Establishment, maintenance and other costs related to management of the trial. Collected data were subjected to statistical analysis using SAS computer software.

Result and Discussion

In the first round of the experiment significant ($P \leq 0.05$) variationswere observed among the treatments for each destructiveand non-destructiveearly growth parametersevaluated. Accordingly, highest value of plant height 93.33 cm was obtained under grass hat treatment followed by Sesbania with mean value of 77.32cm per plant (Table 1). Similarly highest mean stem girth 3.1cmwas recordedunder grass hat (Gojo) treatment followed by *Sesbania Sesban* with mean value of 2.6cmper plant. Number of primary branch of coffee seedling was also considerably affected by shade tree species and highest 24number of primary branch was obtained under grass hat pursued by Sesbaniaand pigeon pea with mean value of 23 and 20, respectively. The same treatment i.e., grass-hat resulted in highest 14 number of node per plant perused by sesbania and pigeon pea with equal mean value of 13 (Table 1).This is due to variation in level of competition among the treatments. For instance grass hat has no competitioneffect on soil nutrients and soil moisture unlike the rest of the treatment. On the other hand less competition effect of sesbania might be due to wider spacing (4m x 4m)used unlike the remaining temporary shade treatments.

Table 1. Effect of temporary shade tree species on non-distractive growth parameters of coffee Seedlings at Jimma in 2009 crop season

Treatment	PH (cm)	Girth (cm)	NPB	No of node
pigeon pea	70.12b	2.3bc	20bac	14ba
Sesbania	77.32ba	26ba	23ba	14ba
grass hate	93.33a	31a	24a	15a
Tephrosia	60.91b	20c	17c	13b
Tephrosia	68.68b	23bc	19c	13b
castor bean	65.04b	22bc	19c	13b
C.V %	14.75	15.51	13.93	6.33
LSD(0.05)	19.48	4.01	5.41	1.59

Where PH= plant height NPB= number of primary branch, and means within a column followed by same letter(s) are not significantly different at $P \leq 0.05$ probability level

Coffee tree under pigeon peaplot showed good growth performance due to its deep taproot system and thus drought tolerance (Morais, *et al*., 2008) and hence less competition on young coffee plantation if it is properly spaced. In the first round evaluation destructive growth parameters of coffee seedlingswere not collected due to snow mixed heavy rain damage on young coffee plantation and uprooting of the temporary shade tree species.
The data on other set of non- destructiveearly growth parameters are presented inTable 2. The result showed that significant ($P\leq 0.05$)variation among treatments for each growth parameters studied. Consequently, highest first primary branch length 45cm was detected from grass hat treatment followed by *Sesbania sesban* and Pigeon pea with respective mean value of 39 and 37 cm (Table 2). Moreover highest leaf number of 221 was also produced from grass hat treatment. Statistically comparable mean values of leaf number 149 and 163 were recorded from pigeon pea and *Sesbania sesban*treatments*,* respectively. Furthermore, height up to first primary branch of coffee tree was significantly ($P\leq 0.05$) affected by temporary shade treatment. In this regard highest mean height up to first primary branch was observed from grass hat treatment. In this case, except tephrosia treatment, there was no significant variation among the rest of the treatments (Table 2). This might be closely associated with wider canopy coverage and close spacing used and hence more competition effect for microclimatic and soil resources. For instance, Pigeon peais drought tolerant and can survive under very dry conditions because of its deep root system. In this regard it has been found to grow during the period of six dry months (Cook *et al*., 2005).

Table 2. Effect of temporary shade tree species on non-distractive growth parameters of coffee Seedlings at Jimma in 2009crop season

Treatment	FPBL (cm)	HFPB (cm)	NLP
Pigeon pea	37^{ab}	21^{ab}	149^{ab}
Sesbania	39^{ab}	22^{ab}	163^{ab}
Grass hat	45^{a}	24^{a}	221^{a}
Tephrosia	33^{b}	20^{b}	113^{b}
Castor bean	35^{b}	23^{ab}	102^{b}
C.V %	14.48	8.01	32.01
LSD(0.05)	9.35	3.21	81.8

Where FPBL= first primary branch length, HFPB= height up to first primary branch, NLP=number of leaf per plant, and *means within a column followed by same letter(s) are not significantly different at $P \leq 0.05$ probability level.*

In the second round of theexperimenttwo treatments namely Leucaena species and no shade or openplot as control was included in the evaluation. Accordingly significantly highest 55.68cm plant height was recorded under grass hat treatment followed by control and *Sasbania sesban* with respective mean value of 48.56 and 50.63cm. The result is in agreement with first round results.Stem girth, number of node and branch were significantly affected by temporary shade treatments. In this case highest 0.57mean stem girth and16.13number of branch wereobtained under sesbania and Grass hat treatments. On the other hand, highest number of node was obtained under pigeon pea perused by sesbania (Table 3). In contrast caster bean resulted in lowest 0.41cm mean stem girth among the treatments. The result is in agreement with first round experiment. Furthermorein study undertaken in Brazil, Pigeon pea has high potential as agro forestry component in coffee plantations, because it protects young coffee plantations from frosts (Caramori *et al*., 1999) and winds and fixes nitrogen symbiotically from the atmosphere, and improve soil physical property and fertility through deposition of leaves and recycled nutrients (Seiffert *et al*., 1988).

Table 3. Effect of temporary shade tree species on non-distractive growth parameters of coffeeseedlingat Jimma

in 2012crop season

Treatment	PH (cm)	Girth (cm)	No. node	No. branch
Sesbania	50.62[ab]	0.56[a]	13.02[ab]	16.13[a]
Tepherosia	45.56[bc]	0.48[ab]	11.94[cd]	13.11[bcd]
Pigeon pea	44.98[bc]	0.44[ab]	13.16[a]	12.98[bcd]
Castorbean	40.44[c]	0.41[b]	11.88[d]	10.80[d]
Grass hat	55.68[a]	0.57[a]	12.80[abc]	14.06[abc]
Leucaena	46.23[bc]	0.44[ab]	12.19 [abcd]	12.02[cd]
Control	48.56[ab]	0.47[ab]	12.44[abcd]	14.83[ab]
C.V (%)	9.57	16.04	4.00	10.74
LSD(0.05)	8.076	0.137	0.890	2.565

Where PH= plant height and means within a column followed by same letter(s) are not significantly different at P≤ 0.05 probability level.

The remaining non-destructive growth parameters data were presented in Table 4. Consequently significantlyhighest 24.41cm primary branch length was recorded under grass hat treatment followed by *Sesbania sesban* and control plots with respective mean value of 22.66 and 20.96 cm. In contrast considerably lowest 14.64cmprimary branch length was obtainedunder caster bean plot.Furthermore seedling canopy diameter was also significantly affected by temporary shade treatments. In this regard highest mean value 33.23cm was obtained under grass hat treatment though the difference was not substantial from sesbania, tephrosia, pigeon pea and open plot. On the other hand lowest mean value 23.94 cm was recorded under caster bean plot.

Table 4. Effect of temporary shade on branch length, canopy diameter and leaf number of youngcoffeeseedlings at Jimma in 2012crop season

Treatment	Branch length (cm)	Canopy diameter (cm)	No. leaf
Sesbania Sesban	22.66[ab]	30.44[ab]	13.73[a]
Tepherosia	19.22[b]	27.69[abc]	12.10[ab]
Pigeon pea	18.70[bc]	28.37[abc]	10.93[b]
Castor bean	14.64[c]	23.94[c]	7.93[c]
Grass hat	24.41[a]	33.23[a]	12.70[ab]
Leucaena	19.14[b]	27.41[bc]	11.93[ab]
Control	20.96[ab]	28.28[abc]	13.24[ab]
C.V (%)	12.03	11.40	12.03
LSD(0.05)	4.2736	5.7761	2.5253

**Means within a column followed by same letter(s)are not significantly different at P≤0.05 probability level*

Variation in leaf number among treatments was also significant (P≤0.05). Consequently highest number of leaf was produced under *Sesbania sesban*. Whereas, the lowestmean value was obtained from caster bean treatment (Table 4).The enhanced early growth response of coffee seedlings under open plot is due to increased competition effectby most temporary shadetree species except *sesbania sesban* due to closer inter-row spacing used. Sesbania was planted at wider inter and intra spacing of 4 m unlike the other species. Furthermore, the comparably good response of open plot observed during the study period might be associated with limited and uneven distribution of rain fall received and high temperature or increased gap between two extremes (maximum and minimum) temperature during the 2012 crop season (Figure 1).

Table 5, 6 and 7 presents data on destructive growth parameters of young coffee plantation. Leaf and branch dry weight was significantly affected by temporary shade tree. Accordingly, highest131.43gram per plantdry weight was recorded from coffee trees grown under grass hat treatment followed by sesbania with mean value of 115.92 gram per plant. Leaf dry weight was also significantly affected by temporary shade treatments. In this regard, highest 54.49 gram per plantleaf dry weight was obtained under control plot followed by *Sesbania sesban* and grass hat treatment with respective mean value of 50.92 and 46.38 gram per plant(Table 5). Coffee tree branch fresh and dry matter was also significantly affected by temporary shade. Accordingly, highest 84.94 branch fresh and dryweight36.41gram per plant was obtained from grass hat treatment followed by sesbania with mean fresh of 70.46 gram per plant and dry weight of 32.52 gram per plant;whereas lowest fresh weight22.85 and dry weight9.81gram per plant was detected under caster bean treatment (Table 5).There was significant difference among treatments for stem and root fresh and dry weight yield. Accordingly, highest 142.56 mean fresh and 87.39dry weight was recorded under grass hat treatment followed by sesbabia with meanfresh 127.78 and dry weight of 79.86gram per plant.Similarly, grass hat gave highest65.46 gram per plantfresh and 39.44 gram per plant dry weight yield of root pursued by sesbania with mean value of 60.46 gram per plant fresh and 37.53 gram per plantdry weight yield (Table 6).Next to grass hat and *sesbania sesban* treatments the controlled plot offered better fresh and dry weight of young coffee seedlings further indicating the enhanced competition effect of closely spaced temporary shade tree species with young coffee trees and similar result has been report byMoraiset *al.*(2008). Significantly highest 424.39 and 209.62 gram per plant total fresh and dry weightwere recorded under grass hat treatmentpursued by *sesbania sesban*treatment with respective mean fresh and dry weight of 374.19and 200.28 gram per plant (Table 7). On the other hand lowest total plant fresh and dry weight of 139.92 and 70.57 gram per plant was recorded from coffee tree grown under castor beanplot in that order. Even though statistically insignificant total root length of young coffee trees varied among temporary shade treatments. Accordingly highest 38.42and lowest 31.58cm per plant of total root length were recorded under grass hat and castor bean treatments, respectively. On the other hand, root volume of coffee tree varied significantly among the treatments. Consequently, highest 58.42 cm^3 of root volume was detected under grass hat treatment followed by sesbania and control plots with equal mean value of 54.42 cm^3 (Table 7).Due to closely spaced temporary shade tree species such as pigeonpea and tephrosia there is noticeable competition effect for soil moisture and light unlike sesbania that was established under wider inter and intra spacing. In this regard a radiation of high temperature can be favourable for coffee Arabica development. Visible symptoms of damage are caused by overheating and excess radiation intensity (Willey, 1975).

Table 5. Leaf and branch fresh and dry matter yield of young coffee tree as affected by temporary shade in 2012 crop season

Treatment	**LFW (g/pl.)**	**LDW (g/pl.)**	**BFW (g/pl.)**	**BDW (g/pl.)**
Sesbania sesban	115.92^{a}	50.38^{a}	70.46^{ab}	32.52^{a}
Tepherosia	71.08^{ab}	28.00^{ab}	42.70^{ab}	19.25^{ab}
Pigeon pea	69.17^{ab}	31.34^{ab}	38.83^{ab}	17.12^{ab}
Castor bean	33.38^{b}	12.80^{b}	22.85^{b}	9.81^{b}
Grass hat	131.43^{a}	46.38^{a}	84.94^{a}	36.41^{a}
Leucaena	99.52^{ab}	38.30^{ab}	64.86^{ab}	25.80^{ab}
Control	95.15^{ab}	54.49^{a}	61.48^{ab}	26.33^{ab}
C.V(%)	48.41	47.902	52.637	52.331
LSD(0.05)	75.752	31.857	51.653	22.24

LFW= leaf fresh weight, LDW= leaf dry weight, BFW= Branch fresh weight, BDW= branch dry weight, g/pl= gram per plant. Means within a column followed by same letter(s) are not significantly different at P≤ 0.05 probability level.

Table 6. Stem and root fresh and dry weigh) of coffee seedlings as affected by temporary shade tree species in 2012 crop season.

Treatment	SFW	SD	RFW	RDW
Sesbania sesban	127.78^{ab}	79.86^{ab}	60.03^{ab}	37.53^{a}
Tepherosia	78.12^{abc}	49.43^{abc}	43.26^{cd}	26.51^{bc}
Pigeon pea	71.94^{bc}	42.84^{bc}	37.69^{cd}	23.76^{bc}
Castor bean	48.70^{c}	27.01^{c}	35.00^{d}	20.95^{c}
Grass hat	142.56^{a}	87.39^{a}	65.46^{a}	39.44^{a}
Leucaena	66.25^{bc}	56.45^{abc}	47.51^{abcd}	29.91^{abc}
Control	74.66^{abc}	59.89^{abc}	55.85^{abc}	33.88^{ab}
C.V(%)	44.125	40.424	21.173	20.453
L SD(0.05)	68.408	41.388	18.554	11.019

SFW=stem fresh weight, SDW= stem dry weight, RFW= root dry weight and RDW=root dry weight, means within a column followed by same letter(s) are not significantly different at (P≤ 0.05) probability level.

Table 7. Coffee distractive growth parameters as influenced by temporary shade in 2012 Crop season

Treatment	TFW	TDW	TRL (cm)	RV (mm)
Sesbania	374.19^{ab}	200.28^{a}	38.42	54.42^{a}
Tepherosia	235.16^{abc}	123.19^{ab}	35.58	36.17^{b}
Pigeon pea	217.63^{bc}	115.06^{ab}	36.39	33.75^{b}
Castorbean	139.92^{c}	70.57^{b}	37.17	30.50^{b}
Grass hat	424.39^{a}	209.62^{a}	31.58	58.42^{a}
Leucaena	303.06^{abc}	150.45^{ab}	31.71	42.92^{ab}
Control	314.80^{abc}	167.85^{ab}	34.25	54.42^{a}
C.V(%)	39.568	37.142	12.153	21.347
LSD(0.05)	202.04	97.89	NS	16.85

TFW= total fresh weight, TDW= total dry weight, TRL= total root length and RV=root volume and mean in a column followed by same letter(s) are not significantly different at P ≤ 0.05 probability level.

The relatively higher total dry matter yield detected under open plot indicates that there was a high competition effectdue to closely spaced temporary shade tree species with young coffee trees. Similar to the present finding,there is some evidence that, especially in recent years, poor smallholder farmers are turning to agro-forestry as a means to adapt to the impacts of climate change. A study from the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) found from a survey of over 700 households in East Africa that at least 50% of those households had begun planting trees on their farms in a change from their practices 10 years ago (Kristjanson *et al*., 2012). Same authors further indicated that shade trees ameliorate the effects of climate change by helping to stabilize erosion, improving water and soil quality and providing yields of fruit, tea, coffee, oil, fodder and medicinal products in addition to their usual harvest. Thus agro-forestry was one of the most widely adopted adaptation strategies in the study, along with the use of improved crop varieties.

Data on weed biomass yield monitored on each experimental unit is presented in(Table 8). Significant ($P\leq 0.05$) variations were detected among the treatment for fresh and dry weed biomass yield. Consequently highest262.27 and lowest134.53 ton per hectare (ha) of fresh weed biomass yield was obtained under control and tepherosia plots, respectively. Furthermore dry weed biomass yield was highest51.05 and lowest23.13ton per ha dry weight under control and tepherosia plots, respectively.Similar to our present research work (Kristjanson *et al*., 2012) reported that dense shading with *pigeon pea* caused significant impacts on coffee performance in the North of Paraná State of Brazil.In line with these, pigeonpea offers the benefits of improving long-term soil quality and fertility when used as green manure (Onim *et al*., 1990), cover crop (Bodner *et al*., 2007). Pigeonpea has been used successfully in coffee plantations as a cover crop to improve soil properties, reduce weed competition. Shade trees also ameliorate the effects of climate change by helping to stabilize erosion, improving water and soil quality and providing yields of fruit, tea, coffee, oil, fodder and medicinal products in addition to their usual harvest.

Table 8. Effect of temporary shade tree on weed biomass (fresh and dry matter) yield(kg/ha) in 2012

Treatment	**FWB (ton/ha)**	**DWB (ton/ha)**
Sesbania	143.11[c]	26.44[c]
Tepherosia	134.53[c]	23.13[c]
Pigeon pea	160.08[bc]	23.59[c]
Castor bean	217.93[ab]	47.14[ab]
Grass hate	186.16[bc]	31.22[bc]
Leucaena	213.52[ab]	32.02[abc]
Control	262.27[a]	51.05[a]
C.V(%)	20.41	33.11
LSD(0.05)	68.359	19.743

FWB= Fresh weed biomass and Dry weed biomass and mean in a column followed by same letter(s) are not significantly different at P≤ 0.05 probability level

Conclusion

Arabica coffee performs best when grown under suitable shade tree species with properly designed cropping system. In this regard both temporary and permanent shade trees should be planted some times before transplanting coffee seedlings. It is basically appropriate if the permanent shade trees are planted a year before transplanting coffee seedlings. On the other hand it is advisable to plant suitable temporary shade tree species one to two months before transplanting of coffee seedlings. Temporary shade tree should be cut- down after two to three years i.e., after the permanent shade tree fully grown and provide enough shade to young coffee plantation. The growth of temporary shade trees should be controlled through slashing or pruning the side branches so as to avoid interlocking with branches of coffee tree.

The slashings provide substantial amount of organic matter that could improve the physical condition the soils. Leaf fall and cutting from the leguminous shade trees could enhance the soil organic matter content and soil fertility status. By recycling the soil nutrient through their leaf litter falls, the use of temporary shade is undoubtedly advantageous in maintaining the soil condition and the microclimate of coffee plantation. Shade tree also protects the soil from direct sun light which might be detrimental to the soil micro-organisms and the upper layer of the humus. Shade also improves the hydrological condition of coffee as well.From result of the present study it can be concluded that locally constructed grass hat (''Gojo'')gave best coffee seedling growth response and can be used in areas with shortage of ample soil moisture or rain. However in areas with ample rainfall or soil moisture Sesbania sesban and Pigeonpea can be used as temporary shade for coffee seedlings if planted under wider spacing (4 m x 4 m) sesbania and (2 m x 2 m) pigeonpea so as to reduce their competition effect with young coffee tree for the limited microclimatic and soil resources.

Acknowledgements

The author would like to acknowledge coffee agronomy project team members of jimma Agricultural research Center for their unreserved participation in data collection. We would like to extend our indebtedness to anonymous reviewers of the journal for their constructive criticisms.

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Appendices

Appendix Table.1; Effect of temporary shade tree on soil properties result from soil laboratory at JARC

Treatment	PH (1:2.5)	%N	%OC	%OM	Available P ppm Bray II	Available meqk/100g	Exchange. Acidity (meq/100g)	CEC (meq/100g)

Sesbania	4.53	0.23a	3.74ab	6.45ab	0.84	2.30a	1.64	20.20a
Tepherosia	4.42	0.14ab	3.49b	6.02b	1.75	1.98abc	2.22	19.99a
Pigeonpea	4.43	0.13ab	3.54b	6.10b	0.39	1.69abc	2.24	18.48ab
Castorbean	4.54	0.20ab	3.80ab	6.56ab	0.77	2.12ab	1.83	17.19c
grass hate	4.40	0.21ab	4.64a	8.00a	0.82	2.02abc	2.39	18.63ab
Control	4.37	0.12b	3.54b	6.10b	1.71	1.41c	1.91	17.84abc
Lussinea	4.34	0.13ab	3.51b	6.05b	0.44	1.48bc	2.78	15.65c
C.V %	3.08	34.03	15.48	15.51	26.98	21.13	40.34	7.97
LSD(0.05)	NS	0.10	1.03	1.78	NS	0.66	NS	2.59

Where mean in a column followed by same letter(s) are not significantly different at P≤ 0.05 probability level

Appendix Table 2. Effect of different temporary shade tree species on soil moisture content (SMC) for 2013/2014 cropping season

Treatment	SMC (%)
Sesbania	13.75
Tepherosia	15.41
Pignpea	16.19
Castorbean	14.06
grass hate	11.55
Control	11.69
Lucinea	13.44
CV(%)	20.41
LSD(0.05)	4.98 (NS)

Appendix Figure 1. Rain fall in (mm) and mean maximum and minimum temperature in (°C) in 2008 and 2012 crop seasons at Jimma

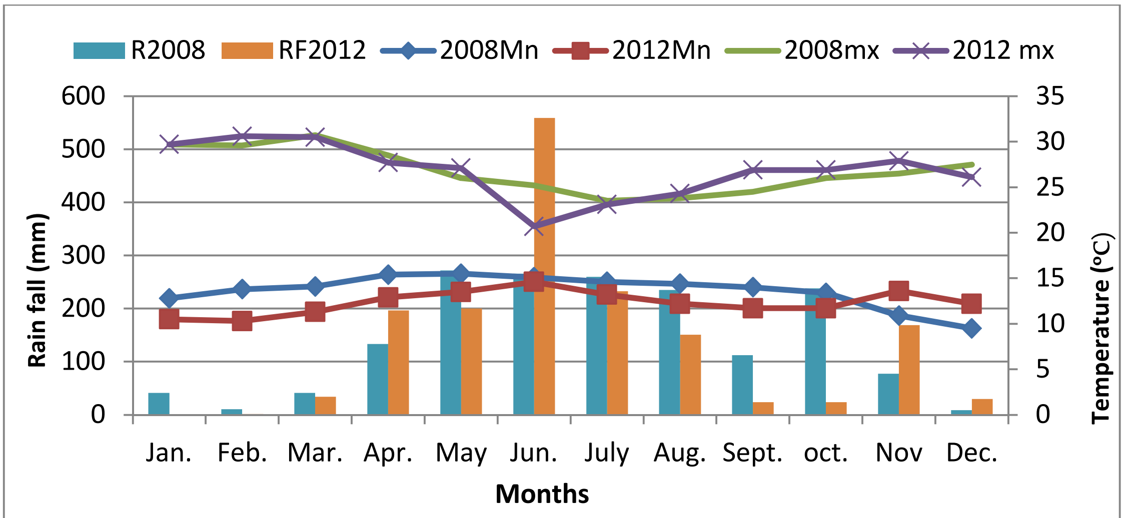

Figure 1. Mean monthly rain fall (mm) and mean maixmium and minimum
air tempreture (°C) at Jimma during 2009 and 2012 crop season