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Research Article

Agronomic Evaluation of Common Bean and Tef (Eragrostis tef) Varieties in Double Cropping System

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Abstract

Double-cropping cereals with legumes is a usual practice by smallholder farmers in southern Ethiopia. However, crop compatibility and sequencing are the major problems for their soil fertility and profitability. Thus, it was useful to conduct experiments on double cropping systems that enable the farmers more profitable on small land to reduce crop failure with current climate change. Thus, an experiment was done to evaluate the effects of the common bean as double cropping on the productivity of tef and to evaluate the economic and technical compatibility of common bean-tef in a double cropping combination to improve production at Wondo Genete district during the cropping season of 2021 using RCBD design. The experiment consisting of twelve treatments including three common bean and three tef varieties was sowed as the preceding and succeeding crop respectively and three sole tef variety to see the compatibility of common bean and tef varieties. The preceding crops showed a non-significant difference in days to maturity, seed per pod, and hundred seed weight, but the biomass and grain yield of Remeda were significantly higher than Awash-2 however, it had no significant yield difference with Hawassa Dume. The variance analysis showed that all the growth and yield parameters of tef were significant such as days to heading, days to maturity, plant height, spike length, number of tillers per plant, tiller number, and grain yield ($p<0.05$). However, the yield parameters like dry biomass, straw yield, and toughened seed weight for tef had no significant difference.

Keywords

Double Cropping, Common Bean-Tef, Boset, Hawassa Dume

1. Introduction

Tef (Eragrostistef (Zucc.)) belongs to the grass family poaceae and it is among the major cereals of Ethiopia [17]. Ethiopia is the center of both the origin and diversification of teff and its domestication is anticipated to have happened somewhere in the range of 4000 and 1000 BC [26]. It has the largest value in terms of both production and consumption in Ethiopia [16, 23]. Tef is first in area coverage and second in total annual production next to maize and ranks the lowest yield compared with other cereals grown in Ethiopia [9, 5, 22]. The national tef productivity is 18.82 qt /ha [9, 23]. On the other hand, the common bean (Phaseolus vulgaris L.) is the most important pulse crops grown in Ethiopia in area coverage and amount of production. it stands second in area coverage and total annual production next to faba-beans and ranks fourth in yield compared with other pulses grown in Ethiopia [9].

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Low soil nitrogen (N) availability is often the major nutrient factor limiting crop productivity [4]. Applying inorganic N fertilizer has become useful way to increase crop yields and grain quality in large scale agricultural systems [4]. However, a high amount of the applied N fertilizer is often lost due to surface runoff, leaching, soil denitrification, volatilization, and gaseous plant emission. Therefore, N management is essential to enhance economic yield, optimum water utilization, and reduce environmental pollution [8]. One of the solutions to increase soil nitrogen in an environmentally friendly manner is a legume and cereal double cropping system. Legumes can fix and incorporate nitrogen into the soil and improve soil structure, avoiding the formation of a hardpan and promoting better aeration [7]. legumes increase soil fertility through the action of microorganisms, which are imperative to affect the soil properties, including soil biological, chemical, and physical properties [25]. The maximal benefit from biological nitrogen fixation systems can be recognized by integrating legumes into agricultural systems, extending the benefits of biological nitrogen fixation to crops and cropping systems [14]. The well-known agricultural systems of integrating legumes into cropping systems include intercropping, crop rotation, double cropping, green manuring, relay cropping, and improved fallows. Double cropping could maximize benefits from the same area and season. It is key to look for the best combination and compatibility of crops to exhaust the opportunity from the system. It was reported that double cropping has many advantages, such as reducing field loss due to insects, drought, and disease, and obtaining a better use of vertical space and time in limited farmland [6].

The Agricultural Production Systems Simulator model was used to give insights into the N contribution, yield benefit to cereals, and overall economic performance of the inclusion of pulses into the double cropping [12]. Legume crops contribute to 15% of the N in an intercropped cereal and mitigate the emission of greenhouse gases (GHGs) by reducing the application demand of synthetic nitrogenous fertilizers [18]. The result of [20] indicated that farmers adopted in and around Bauchi state for higher yielding applied 60kg N/ha as a top dress to sorghum on cowpea or soybean residue. The cereal monocropping was the most profitable but not the most sustainable; N deficiency reduced yield and protein after three crops. The rotation with the cereal immediately followed by a pulse crop was profitable without the need for fertilizer N. When the pulses were grown on fallowed ground (with cereals being double-cropped) economic returns were as good as, and potentially greater than, the cereal/double-crop pulses rotation. According to [11] result, Well-grown chickpea and mung bean crops contributed 51 and 41 kg N/ha, respectively, to the subsequent cereal. The finding by [19], indicated that wheat yield increased by 2196, 1616, 1254, and 1065 kg ha^{-1}, and the N uptake increased by 71.4%, 51.0%, 49.2%, and 29.8% in the faba bean-wheat, 'dekeko'-wheat, field pea-wheat and lentil-wheat rotation plots compared to the wheat continuous cropping, respectively.

Double cropping cereals after pulse cropping could be an alternative to increase the productivity of the crop, although double cropping of pulse with cereals was still under investigation. The application of legume and cereal double cropping was common practice among smallholder farmers as a food source for their family. However scientific studies are rare despite potential advantages to enhance income and satisfy food sources for poor family. The study here sought to link this knowledge gap with a view to increasing the productivity of common bean/tef double cropping systems. Besides offsetting the production shortage of smallholder as well as large-scale agriculture common beans grown as double cropping with tef could have the potential to improve the productivity and the production of crops. Hence, it is necessary to evaluate the effects of common bean and tef as double cropping on the productivity of tef and to evaluate the economic and technical feasibility of common bean-tef in a double cropping combination for an improved production system at wondo Zuria area of Sidama regional state, Ethiopia.

2. Material and Methods

2.1. Description of the Experimental Site

The experiment was conducted at Wendo wereda which is located between latitude at 7° 192 N and longitude 38° 382 E with an altitude of 1780 m a.s.l and found in Sidama Regional State. During the year there is bi-modal rainfall distribution, with a dry spell period during June and July which, depending on its duration, may affect crop growth. As in most of the Horn of Africa, two rainy seasons like Wendo woreda's climate. The first named 'Belg' characterized that the shortest one and takes place between March and May, while the second and the most important is 'Meher' between July and October. The average annual rainfall is 1128 mm. The mean annual minimum to maximum temperature ranges from 11.47 and 26.51 ℃, respectively. The soil textural area of the experimental area was sandy loam with a pH of 6.4 [13].

2.2. Sources of Planting Material and Cultural Practices

The seed of Tef was obtained from the Debrezeyt agricultural research center, while the common bean crop that was used for the experiment was obtained from the Wendo genet agricultural research center. Tef is commonly cultivated in the region with an average yield of 7-16 Q ha^{-1} as stated by Southern Nations, Nationalities and Peoples Regional State's Agriculture Bureau.

The experimental plot was well prepared and the crop was grown as rain-fed. The land was plowed to prepare a suitable seed bed before sowing the components. The seeds of common bean as well as tef were sowed by hand with their spacing. For tef, the intra-row spacing will be 20 cm with line drilling and the common bean crop was planted 10 cm apart from each other and 40 cm between rows. At the time of planting, all plots received a basal application of recommended NPS for tef and common bean, respectively. Generally, crops in these studies were grown with good cultural practices applicable to the areas. Each experimental plot size was 1.4 m in length and 4 m in width respectively.

2.3. Treatments and Experimental Procedure

The experimental crops used for this study were divided into two: preceding and succeeding crops. The crops were selected based on their current and potential importance and mainly for their early maturity. The preceding and succeeding crops used were common bean and tef variety respectively.

A factorial experiment consisting of three common bean varieties was sowed as the preceding crop while the planting of three tef varieties was used as the succeeding crop to see the compatibility of common bean and tef varieties. The treatments of this experiment included: Tef (Boset) with Hawassa dume, Tef (Boset) with Awash-2, Tef (Boset) with Remeda, Tef (Smada) with Hawassa dume, Tef (Smada) with Awash-2, Tef (Smada) with Remeda, Tef (tsedey) with Hawassa dume, Tef (tsedey) with Awash-2, Tef (tsedey) with Remeda and sole of Tef and common bean varieties with recommended fertilizer application (Table 1). Hence, the experiment was laid out in randomized complete block design (RCBD) with factorial combination, where three varieties of Tef and the three common bean varieties combinations plus sole Tef as a control was arranged as treatments, resulting into a total of 12 treatments replicated three times.

Table 1. *Treatment combinations of common bean with Tef varieties in double cropping system.*

Factor A (Tef varieties)	Factor B (Common bean varieties)	combination	Treatment code
Boset	-	Boset (Sol)	T1
Smada	-	Smada (Sol)	T2
Tsedey	-	Tsedey (Sol)	T3
	Hawassa dume	Tsedey + Hawassa dume	T4
Tsedey	Awash-2	Tsedey + Awash-2	T5
	Remeda	Tsedey + Remeda	T6
	Hawassa dume	Boset + Hawassa dume	T7
Boset	Awash-2	Boset + Awash-2	T8
	Remeda	Boset + Remeda	T9
	Hawassa dume	Smada + Hawassa dume	T10
Smada	Awash-2	Smada + Awash-2	T11
	Remeda	Smada + Remeda	T12

2.4. Data Collection on Common Bean

Days to 90% physiological maturity: days to physiological maturity will be recorded when about 90% of the plants reach physiological maturity based on visual observation. It will be indicated by senescence (turning to light yellow) of the leaves and vegetative parts as well as free threshing of grain from the grains when pressed between the finger and thumb.

Seed per Pod: from ten plants the number of seeds per plant from the mature plants' parts will be randomly taken from the net plot area and counted at the time of harvesting.

Above-ground biomass: At maturity, the whole above plant parts, including leaves, stems and pods including seeds from the net plot area in each plot will be harvested and sun-dried until constant weight and then the above-ground biomass will be measured and expressed in kg ha^{-1}.

Grain yield (GY): After harvesting, threshed grains will be separated, cleaned, and weighed by electronic balance. The grain yield will be corrected to a moisture content of 11%, wet bases while moisture tester will be employed for measuring the moisture content.

Hundred seed weight (g): hundred seed weight will be counted by the electronic counter and weighed by electronic balance later 100-seed weight will be expressed in grams.

2.5. Data Collection on Tef

Plant height of Tef: at time of maturity plant height of 10 selected plants will be taken randomly from the net plot area of each plot then the height will be measured from the ground to at terminal stem.

Days to 50% flowering: days to flowering will be recorded when about 50% of the plants in a plot produce flowers.

Days to 90% physiological maturity: when the tef plant is 90% matured.

Panicle length: measure the length of the panicle by using a meter.

Days to heading: count the days to grow a heading.

Above ground biomass weight (kg ha^{-1}): at the time of maturity, the whole above plant parts, including leaves, stems including seeds from the net plot area in each plot will be harvested and oven-dried at 100oc for 24 hours until constant weight and then the above-ground biomass will be measured and expressed in kg ha^{-1}.

Grain yield (kg ha^{-1}): After harvesting, threshed grains will be separated, cleaned, and weighed by electronic balance. The grain yield will be corrected to a moisture content of 12.5%, wet bases while a moisture tester will be employed for measuring the moisture content.

2.6. Economic Analysis

The partial budget analysis will include the average yield for each treatment, adjusted yield, and gross benefit. Then dominance analysis will be carried out to compare the increase in terms of cost that varies with its respective benefits.

2.7. Data Analysis

All data will be subjected to the analysis of variance (ANOVA) appropriate to the randomized complete block design using SAS (SAS, 2002). The least significant difference (LSD) test at 5% level of probability will be also used for mean separation as procedure described by Gomez and Gomez, (1984) and the linear model of RCBD will be used.

3. Results And Discussions

3.1. The Variance Analysis of Major Traits of Tef Varieties in the Double Cropping System

The analysis of variance showed that all the agronomic parameters were significant such as days to heading, days to maturity, plant height, spike length, number of tillers per plant, and grain yield ($p<0.05$). The result of mono-cropped tef varieties, the variety Boset and Tsedey took significantly the longest time to head as compared to the variety Semada. But the varieties Boset and Semada took significantly the longest and the shortest time to head when double-cropped with the three common bean varieties respectively. However, the variety Boset took somewhat the same heading time solely and in a double cropping system with common bean varieties. On the other hand, the common bean variety Awash-2 somewhat lowered the heading time of Tsedey and Semada when it was sown in a double cropping system (Table 2).

Table 2. *Mean effect of common bean and Tef varieties on days to heading, days to maturity, plant height, and panicle length of Tef.*

Tret	Treatment	Days to heading	Days to maturity	Plant height	Panicle Length
1	Boset	56.00a	95.67abc	81.23ab	29.70a
2	Semada	46.00d	91.67c	72.53def	23.47ef
3	Tsedey	52.67abc	91.67c	82.23a	29.00ab
4	Tsedey + Hawassa dume	53.00ab	97.33abc	71.23ef	28.20ab
5	Tsedey + Awash-2	47.00cd	97.33abc	78.03abcd	28.80ab
6	Tsedey + Remeda	52.33abc	102.00a	74.53cde	26.13bcde
7	Boset + Hawassa dume	56.00a	99.67ab	74.97bcde	27.03abcd
8	Boset + Awash-2	56.00a	94.00bc	80.00abc	30.33a
9	Boset + Remeda	56.00a	102.00a	72.63def	27.47abc
10	Semada + Hawassa dume	45.67d	98.00abc	67.70f	23.60def
11	Semada + Awash-2	49.67bcd	93.33bc	67.23f	22.47f
12	Semada + Remeda	45.67d	91.67c	69.57ef	24.07cdef
	LSD	5.91	7.10	6.63	3.49
	CV	6.80	4.36	5.27	7.73

Tret	Treatment	Days to heading	Days to maturity	Plant height	Panicle Length
	Sig	**	*	**	**

The analysis of variance showed that the variety Boset significantly took the longest time to mature as compared with the Semada and Tsedey varieties in the mono-cropping system. According to [1] similar result was reported that days to maturity of the sorghum was highly significantly (P <0.01) affected by the preceding crop. The three tef varieties showed an increment in days to maturity under a double cropping system, the result was raised because of the residual nitrogen effect of the precursor crop. This result aligns with the report of [2] who stated that increasing the rate of nitrogen from 18 to 36 kg N ha^{-1} days to maturity by about relatively shorten days as compared to that of 66 kg N ha fertilizer rate, which was a very prolonged maturation, date and hasten the vegetative phase of teff. However, the increment was insignificant except for the days to maturity of the variety Boset. The days to maturity of Tsedey and Boset (102 days) were significantly longer than the variety Semada when cropped with the common bean variety of Remeda whereas the two Tef varieties cropped with the Awash-2 common bean variety had the shortest days to maturity in the double cropping system (Table 2).

Panicle length and Plant height were highly significantly (P < 0.01) influenced by the common bean varieties, similarly, [1] reported that Panicle length and Plant height were highly significantly (P < 0.01) affected by the legumes planted as a preceding crop. The tallest plant was observed by the variety of Tsedey (82.233 cm) but it had no significant difference with the variety Boset (81.233 cm) in the sol cropping system, which was observed due to its genotypic expression similar result was also observed by [15]. Similarly, the longest panicle length was also observed on the variety of Tsedey and Semada but no significant difference with the monocropping system, a similar result was reported by [10] stated that the tef varieties displayed highly significant (P <0.001) difference for all recorded traits except panicle length. On the other hand, the plant height and the panicle length of the Tsedey and Boset varieties after the common bean variety of Awasha-2 were longer than the Semada variety.

The variance analysis of tiller number showed that non-significant difference with sol cropping of Tef varieties, the variety of Semada sown after the common bean variety of Hawassa dume harvested had a greater number of tillers as compared to the other combinations. But a significant difference between Tef and common bean varieties combination in the double cropping system, for instance, the variety Awasha-2 is more compatible with Tsedey and Boset varieties to produce a great number of tillers.

According to the result, the maximum straw yield and dry biomass were recorded on sol cropped tef variety of Boset which was not significantly different from sol as well as the double-cropped Semada and Tsedey variety. Even if non-significant result the highest thousand seed weight was recorded at the combination of Awash-2 and the three tef varieties. On the other hand, a significantly higher grain yield was recorded from the sol-cropped Boset tef variety similarly [3] reported that the maize that followed the legume achieved a higher grain yield than the one following barley reducing the fertilizer needs. However, this result was not significantly different from the grain yield of Tsedey sown after Hawassa dume and Boset after awash-2 of the common bean variety.

Table 3. *Mean effect of common bean and Tef varieties on tiller number, dry biomass, and grain yield of Tef.*

Tret	Treatment	Tiller Number	Strow yield t/ha	Dry biomass t/ha	1000 seed weight (gm)	Grain yield Qt/ha
1	Boset	6.00abc	5.37a	8.53a	0.31a	17.01a
2	Semada	6.87ab	4.66ab	6.60abc	0.29a	10.57bcd
3	Tsedey	6.43ab	4.24abc	6.33abc	0.38a	11.81bcd
4	Tsedey + Hawassa dume	5.97abc	3.50bc	5.67bc	0.29a	13.65ab
5	Tsedey + Awash-2	6.47ab	3.34c	4.93c	0.32a	9.56cd
6	Tsedey + Remeda	4.63c	4.32abc	6.27abc	0.32a	10.51bcd
7	Boset + Hawassa dume	5.50bc	4.04bc	6.20abc	0.34a	11.36bcd
8	Boset + Awash-2	5.83abc	4.34abc	6.47abc	0.37a	13.56ab
9	Boset + Remeda	5.57bc	3.97bc	7.40ab	0.33a	11.07bcd

Tret	Treatment	Tiller Number	Strow yield t/ha	Dry biomass t/ha	1000 seed weight (gm)	Grain yield Qt/ha
10	Semada + Hawassa dume	7.40a	3.67bc	5.27bc	0.33a	8.24d
11	Semada + Awash-2	5.30bc	4.16abc	6.13bc	0.36a	9.79cd
12	Semada + Remeda	6.13abc	4.03bc	6.07bc	0.35a	12.04bc
	LSD	1.57	1.22	2.38	0.10	3.61
	CV	15.45	17.42	22.24	18.44	18.37
	Sig	*	NS	NS	NS	**

3.2. Analysis of Variance of Major Traits of Common Bean Varieties in the Double Cropping System

The Analysis variance showed a non-significant difference in days to maturity, seed per pod, and hundred seed weight of common bean varieties. According to the analysis of results, the biomass of Remeda was significantly higher over the Awash-2 but Remeda had almost comparable biomass yield with the Hawassa dume common bean variety. Similarly, the grain yield of Remeda was significantly higher than Awash-2 but had no significant yield difference with Hawassa Dume, similarly reported by [21] stated that the biological and grain yield of Remeda was significantly higher than Awash-2 but non-significant-result with Hawassa dume. According to the report of [27] Even if the highest grain yield of Remeda, the variety Awash-2, and Hawassa dume are preferred by the farmers over the Remeda variety.

Table 4. *Mean effect of common bean and Tef varieties on days to emergency, dry biomass, and grain yield of common bean.*

Tret	Treatments	Days to maturity	Seed per pod	Dry Biomass qt/ha	Grain yield Qt/ha	100 seed weight
1	Hawassa dume	107.67	4.77	37.23abc	23.76ab	23.07
2	Awash-2	108.56	4.67	23.37cd	13.05d	28.97
3	Remeda	103.00	4.63	41.05ab	23.75ab	35.01
4	Tsedey + Hawassa dume	106.33	5.12	37.47abc	23.27abc	26.47
5	Tsedey + Awash-2	103.00	4.90	24.67cd	14.30dc	37.97
6	Tsedey + Remeda	104.33	4.91	44.69a	26.81a	40.05
7	Boset + Hawassa dume	103.00	5.33	36.99abcd	24.25ab	36.56
8	Boset + Awash-2	106.33	5.33	22.06d	11.80d	49.99
9	Boset + Remeda	103.00	5.69	37.41abc	20.69abcd	36.18
10	Semada + Hawassa dume	102.56	5.02	27.47bcd	17.13bcd	32.01
11	Semada + Awash-2	106.78	4.62	29.59abcd	18.03abcd	24.11
12	Semada + Remeda	106.33	5.09	32.47abcd	19.20abcd	34.99
	LSD	5.67	0.70	15.14	9.15	17.10
	CV	3.19	8.29	27.20	27.47	29.90
	Sig	NS	NS	**	*	NS

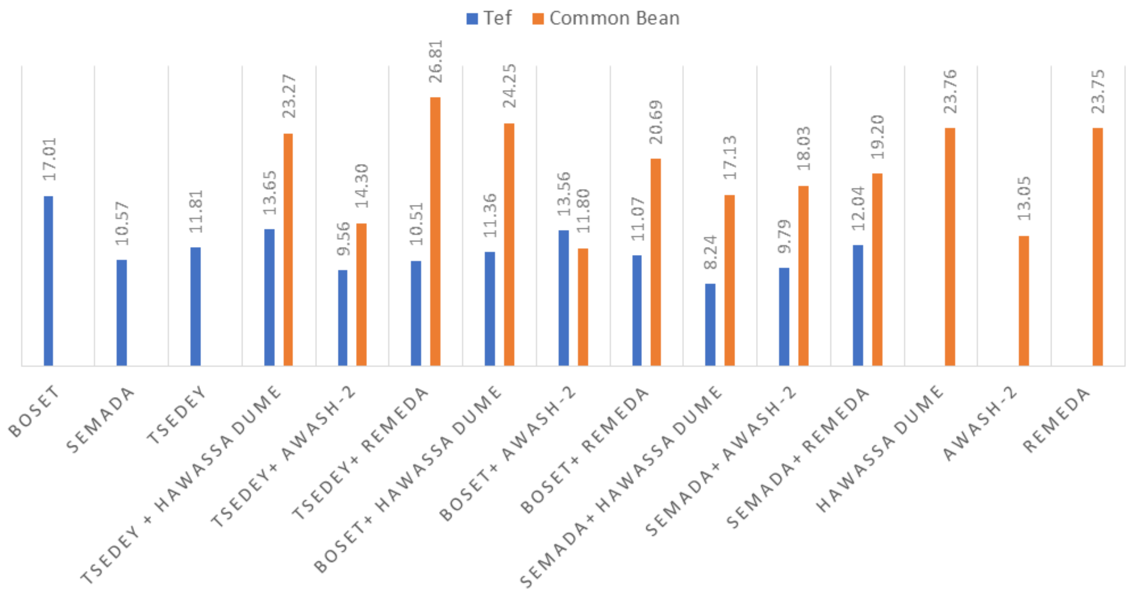

Figure 1. *Yield responses (Qt/ha) of Tef and common bean in double cropping system.*

In general, the highest grain yield of tef was recorded from the Boset tef variety but this result had no significant difference with the double-cropped Tsedey with Hawassa dum and Boset with Awash-2 common bean varieties. However, the yield of Hawassa dum (23.27Qt/ha) was greater than Awash-2 (11.80Qt/ha) by almost 50% grain yield per hectare, due to this reason cropping Tsedey tef variety with Hawassa dume common bean variety had profitable for double cropping system.

3.3. Economic Analysis

The results of the partial budget analyses and the data used in developing the marginal rate of return are given in Table 5. The result of total variable cost (TVC) revealed that sol common bean varieties cost less than other sol tef and common bean-tef varieties combinations plots, a similar result was reported by [24] indicating that the lowest cost and benefit was obtained from sole Habru chickpea variety while the highest cost and benefit was recorded when Natoli chickpea variety was double-cropped with Denekinesh wheat variety. Sole common bean plots had considerably reduced labor and seed costs compared to others. The highest gross field benefit (GFB) and net benefit (NB) were obtained from the combination of Tsedey with, Hawassa-dum (273,359.63 and 204,869.90 ETB ha^{-1}) respectively. On the other hand, the next highest gross field benefit (GFB) and net benefit (NB) were obtained from Tsedey with Remeda, tef, and common bean double cropping system (254,241.50 and 181,080.00 ETB ha-1) respectively. This result showed that sowing the variety Tsedey after common bean varieties in a double cropping system is more profitable tef variety.

Table 5. *Marginal rate of return of tef-common bean double cropping system.*

Treatment	TFAY (kg)	CMAY (kg)	TFADY (kg)	CMADY (kg)	TVC (Birr)	NB (Birr)	GFB (Birr)	CBR	MRR
Bosete + Awash-2	1356.00	1179.44	1411.93	1074.99	65138.84	158041.85	223180.69	3.43	3.82
Tsedey + Awash-2	956.00	1430.15	959.62	1164.01	65514.70	107840.67	173355.37	2.65	D
Smada + Awash-2	978.67	1802.59	1074.50	1553.99	67161.28	139477.82	206639.10	3.08	D
Smada + Hawassa dume	824.00	2211.11	814.81	1774.05	67212.88	101525.97	168738.85	2.51	D
Tsedey + Hawassa dume	1365.33	2327.31	1655.12	1868.62	68489.73	204869.90	273359.63	3.99	4.72
Bosete + Hawassa dume	1136.00	2424.42	1414.11	1922.57	68717.51	177878.78	246596.29	3.59	3.98
Smada + Remeda	1204.00	1919.90	1271.35	2134.13	69610.77	168316.42	237927.19	3.42	3.65
Bosete + Remeda	1106.67	2068.93	1263.64	2286.29	70253.21	172835.28	243088.49	3.46	3.70

Treatment	TFAY (kg)	CMAY (kg)	TFADY (kg)	CMADY (kg)	TVC (Birr)	NB (Birr)	GFB (Birr)	CBR	MRR
Tsedey + Remeda	1050.67	2680.32	1126.98	2975.09	73161.50	181080.00	254241.50	3.48	3.64

ETB = Ethiopian Birr; CBR=Cost benefit ratio, GFB = Gross field benefit; MRR = Marginal rate of return; NB = Net benefit; TVC = Total variable cost; TFAY = Tef Average yield; CMAY= Common bean Average yield; TFADY= Tef Adjusted yield; CMADY= Common bean Adjusted yield.

The dominance analysis, in this experiment, showed that out of tef and common bean varieties combinations, the variety of Tsedey and Smada with Awash-2 and Smada with Hawassa dume combinations were those which had more variable costs, However, the net benefit return was lower than the treatments costing lower than the listed treatments (dominated). Except for the plots treated with the variety of Tsedey and Smada with Awash-2 and Smada with Hawassa dume combinations all the treatments were the un-dominated ones as compared to other combinations (Table 4). The analysis of the marginal rate of return (MRR), on the other hand, showed the return per unit production cost was highest from the Tsedey and Hawassa dume tef and common bean variety combination (MRR = 4.72) (Table 4). Planting the Hawassa dume common bean variety with Tsedey tef variety in a double cropping system at Belg and Mehere season of around shashemene expect to recover 1 Birr and obtain an additional 4.72 Birr return for 1 invested Birr during the production time. This result showed that sowing the Hawassa dume common bean variety at belg season and then after the Tsedey tef variety in a double cropping system was the most successful legume-cereal combination for profitable production compared to the rest of the treatments.

4. Conclusion and Recommendation

The analysis of variance showed that the variety Boset significantly took the longest time to mature as compared with the Semada and Tsedey varieties in the mono-cropping system. The days to maturity of Tsedey and Boset (102 days) were significantly longer than the variety Semada when cropped with the common bean variety of Remeda whereas the two Tef varieties cropped with the Awash-2 common bean variety had the shortest days to maturity in the double cropping system. significantly higher grain yield was recorded from the sol-cropped Boset tef variety. However, this result was not significantly different from the grain yield of Tsedey sown after Hawassa dume (13.65 Qt/ha) and Boset after awash-2 (13.56 Qt/ha) of the common bean variety and this combination is recommended for areas having similar agro ecology with Shashemene district for double cropping farming system. This association has the highest biological efficiency, a good total productivity and monetary return. Thus, the combination is beneficial to meet both the food requirement and cash needs of small holder as well as large scalefarmers.

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Author Contributions

Hailu Garkebo Mola is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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