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EFFECTS OF SEASON AND AGRO-ECOLOGY ON NUTRITIONAL QUALITY OF FOLIAGES OF MULTIPURPOSE TREES AND SHRUBS: PERCEPTIONS AND MEASUREMENTS FOR GLOBAL IMPORTANCE

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ABSTRACT

The productivity of livestock in Ethiopia is low due to scarcity and fluctuating quantity and quality of feed resources. Identify and use of new potential feed resources such as indigenous fodder trees and shrubs (IFTS) could bridge the gap. The present study was aimed to identify and evaluate agro-ecological and seasonal variations of nutrients as well as to estimate potential biomass yield of IFTS collected from low and mid altitude of Gambella region, south-western of Ethiopia. Lare district was selected from the low altitude area (450-700 metres above sea level, masl) where as Godere was selected for the mid altitude area (800-1500 masl). A cross-sectional study was conducted in three Farmers administrations of each district assumed to represent the existing livestock production system purposely. The potential fodder yield productivity of identified shrubs and trees' was estimated by measuring stem circumference using measuring tape. The samples of foliages were collected at dry and wet season and analyzed for their nutritional content. All the surveyed data were analyzed using SPSS version 19 and SAS version 9.2.In the mid altitude region, the contribution of IFTS as livestock feed was found to be 23.33 %, cutting and carrying were the existing practice of feeding animals under various productive status. Agro pastoralists of the lower altitude region were persuasively using the foliages of IFTS during the flooding of the grazing lands in rainy season as well as during prolonged drought periods. As perception of all respondents fluctuation of body conditions of animals indicates the feed shortage in seasons. Flooding for lowland and shortage of grazing land for mid altitude were the main cause of feed shortage during wet season. Twenty seven potential IFTS were identified with variant nutrient content and biomass productivity. Trees have high biomass productivity compared to shrubs across seasons and agro-ecologies (P<0.05).The biomass productivity of browses was higher at mid altitude compared to low altitude (P<0.05). *Ficus sur* and *Vernonia amygdalina* had the highest biomass yield over trees and shrubs (P<0.05). Higher protein content was observed in fodder trees compared to shrubs (P<0.05). It's revealed in the present study that the browse species had NDF of < 45 % and ADF< 35%, these values are indicating high fodder value of IFTS for supplementing livestock. This study also confirms browse plants have significant potential for complementing the dry and wet season feed shortage.

INTRODUCTION

Livestock production plays an important role in Ethiopia's economy (FAO 2010; Funk *et al*., 2012; CSA 2013). In spite of the huge number, the productivity of livestock in Ethiopia is low mainly due to scarcity and fluctuating quantity and quality of the year-round supply of feed resources (NABC 2010; Belachew *et al*., 2013; MoA 2013).

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Natural pastures, crop aftermath and crop residues are contributing more than 90% of the livestock feed in the country. These feedstuffs are considerably low in quality (high in fiber, low in protein, energy and other essential nutrients), but still they serve as the main source of livestock feed (Yisehak *et al*., 2013). Increased expansion of cultivation of grazing lands for cereal crop production, human settlement and urbanization, overgrazing and soil erosion are also visible features that consequences for the overutilization of grazing lands and feed shortage (Abule *et al*., 2005; Yisehak *et al*., 2013). This is also true for Gambella region especially shrinkages of grazing lands for the expansion of large scale farms for cotton, rice, seasam, peanut and coffee production. One potential way for increasing the quality and availability of livestock feeds is the use of various indigenous fodder trees and shrubs (IFTS) (Anyanwu and Etela 2013; Yisehak *et al*., 2012). IFTS species, because of their adaptability to harsh environmental conditions, represent an important fodder bank for herbivore livestock in tropical and subtropical agro-ecosystems (Abdulrazak *et al*., 2001; Rubanza *et al*., 2003). The foliages of IMPTS are relatively rich in most essential nutrients for microbial fermentation and tend to be more digestible than tropical grasses and crop residues (Bonsi *et al*. 1994; El Hassan *et al*., 2000; Aregheore and Perera 2004). A variety of IFTS are growing in Gambella region of Ethiopia, mainly due to the suitability of the environment and the use of them for multiple functions such as fire wood, local construction material, medicinal value, commercial wood production and shade for livestock and several shade loving food and feed crops. However, studies have not yet been done with regard to the potentials of IFTS utilization for livestock of Gambella region. Identification, biomass yield, nutritive value evaluation and prioritization of new potential feed resources could enhance feed security of livestock in the region. Therefore, the objectives of this study was to identify and evaluate agro ecological and seasonal variation of nutrients and estimate potential biomass yield of IFTS at low and mid altitude of Gambella region, south west Ethiopia.

MATERIALS AND METHODS

The study site

The study was carried out in Gambella National Regional State (7°37′06″N, 34°41′22″E), south western Ethiopia. Gambella is located 766 kms from Addis Ababa, the Ethiopian national capital. Gambella region is characterized by hot-humid tropical lowland climate. The region receives average rain fall of about 1228 mm per year. Gambella is characterized by a variety of elevations, 450-2000 masl (Woube 1999). Lare district was selected from the low altitude area of the region 450-700 masl whereas Godere was selected for the mid altitude area ranges 800-1500 masl.

Inventory and evaluation of locally available browse species

a) Use of indigenous knowledge

A cross-sectional study was conducted in Lare and Godere districts representing the low and mid altitude of Gambella region, respectively. Three Farmers administrations (FA) assumed to represent the existing livestock production system were purposely included in the study from each district. A total of one hundred eighty (180) respondents, proportionately from each altitude were selected randomly and interviewed for availability, preference and feeding practises of IFTS in the study area. The total number of households required for the study was calculated based on the formula given by Cochran (1977). A precision level of 5% and 95% confidence interval was used to calculate the sample size using the formula n= Z^2pq/d2. Where, n, desired sample size; Z, abscissa of the normal curve: 1.962, the value of Z at 95% confidence interval; P, estimated proportion that one is trying to estimate in the population; d, degree of accuracy desired/ desired absolute precision level at 95% confidence interval, the probability of Type I error (called alpha).

b) Estimation of biomass yield of browses

The identified shrubs and trees' potential fodder yield was estimated by measuring stem circumference using measuring tape and using the equation of Petmak (1983). Accordingly, leaf yield of fodder trees was estimated by allometric equation of log W = 2.24log DT-1.50. Where, W = leaf yield in kilograms of dry weight and DT is trunk diameter (cm) at 130 cm height. Similarly, trunk diameter (DT) can be obtained by: DT = 0.636C; where C = circumference in centimeter (cm). For the leaf yield of a shrub the allometric equation is log W = 2.62log DS -2.46. Where DS is stem diameter in cm at 30 cm height.

Chemical analysis of selected browse species

The chemical composition of foliages of browse species identified and ranked during cross-sectional survey through questionnaire was determined. Foliage samples were collected both in dry and wet season and dried in air forced laboratory oven. The samples of foliages were grinded in a Wiley mill through a 1mm sieve/screen. The ground samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude ash(ASH), and crude fiber (CF) following AOAC (2005) while neutral detergent fibre (NDF),Van Soest *et al*. (1991), and acid detergent fiber (ADF) was determined sequentially by the method of Van Soest and Robertson (1985). NDF and ADF values were expressed inclusive of residual ash. Lignin (ADL) was determined by solubilisation of cellulose with H_2SO_4 (Van Soest and Robertson 1985). Hemicellulose (HC) was calculated as the difference between NDF and ADF where as cellulose was obtained by subtracting ADL from ADF (Fisher *et al*., 1995). All chemical analyses were carried out in duplicate.

Data analysis

All the surveyed data was analyzed using statistical procedures for social science (SPSS) version 20 (SPSS, 2009). Statistical variations for categorical data was tested by means of cross tabs, with significant differences at $P< 0.05$; while the numerical data was subjected to two way analysis of variance (two-way ANOVA) using the general linear model procedure of SAS (SAS 9.2) was employed for biomass yield estimation and chemical composition; $Y_{ijk} = \mu + S_i + L_j + M_{ij} + \Sigma_{ijk}$ Where, Y_{ij}= Chemical composition and biomass yield. Mean comparisons was carried out using Duncan's multiple range tests. Level of significance also was considered at $P < 0.05$, with μ=overall mean. S_i, the effect i^{th} season / browse type; L_j, the effect of j^{th} altitude; M_{ij}, interaction effect between season / browse type and altitude;e_{ij}, random error

RESULTS AND DISCUSSION

Demographic Characteristics of the Households

In this study, 74.4% of interviewed respondents were male headed families and only 25.6% were female-headed families. The ranges of age distribution of respondents were dominated by those having between 36-50 years (44.44%). In terms of educational status, 54.1% of respondents had formal and informal education, while 45.9% were not educated. From the total respondents, 50% were agro-pastoralists at the low altitude while the remaining 50% relied on mixed agriculture, dominated by coffee and honey production followed by livestock production at the mid altitude of the study area.

Availability of Feed resources

According to 57.78% of mid and 86.67% low altitude area respondents, natural pastures followed by crop residue are the major feed resources of livestock. This result is in agreement with Ebrahim *et al*. (2015) for northern Ethiopia and Negesse *et al*. (2009) for Ethiopia in general. As indicated in figure 1 below 23.33 % of the mid altitude livestock owners practice stall-feeding with zero grazing at cropping season, had habits of using fodder trees and shrubs by cutting and carrying for small and large ruminant fattening. Similar result for Eastern Ethiopia highlands were presented by Haftay and Dargo (2014). The agro-pastoralists of the lower altitude use foliages of fodder trees and shrubs persuasively against recurrent flooding of the grazing lands at rainy season and drought at dry season. When compared to other available feed resources in the low altitude region, foliage's of fodder trees and shrubs were preferred least in the region. This result indicates that there is lack of awareness on the usage of fodder trees and shrubs as potential feed source for livestock.

et al. (2013) reported that ruminants looses of body weight and body condition during feed shortages. In feed scarcity conditions, farmers were forced to use other available feed sources, such as foliages of IFTS. Similar findings in the tropics has indicated browse plants have been found to give significant potential in terms of adoptability, productivity and acceptability for ruminants in order to balance the difficulties of feed shortages in the dry season (Hutagalung, 1981). Furthermore, this study confirmed that the browse plants have significant potential for the wet season feed shortage. Flooding for lowland and subsequent shortage of grazing land (all the land is covered by crops) for mid altitude were the main cause of feed shortage during wet season. Even though there is high production of herbage at wet season there is flooding at low land which forces them shift/ move to high land. At the mid altitude areas, all arable lands have been covered by crops at wet season reducing grazing land. According to this study 15.56 % of farmers prefer that dry season is suitable for livestock production than the wet season in terms of feed availability.

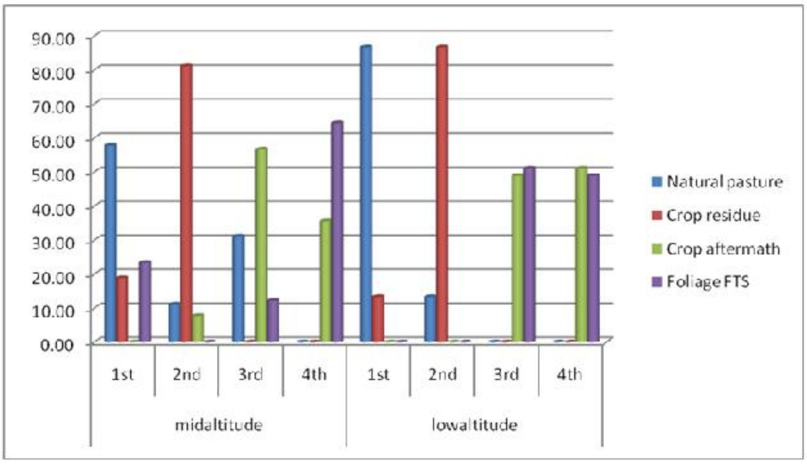

Figure 1. Major feed resource

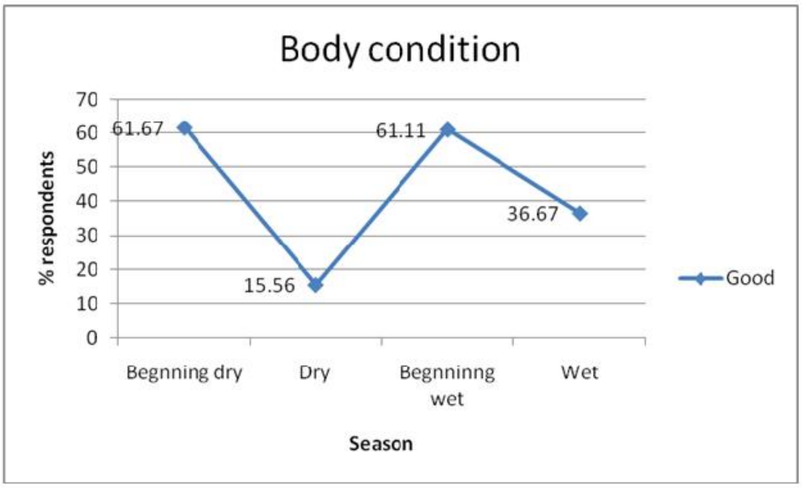

Figure 2. Seasonal body conditions

Seasonal feed shortage for livestock production

The seasonal fluctuation of feed resources availability in terms of quality and quantity was found to be significant in providing sufficient nutrients for the productivity of animals. According to the perception of all respondents, the body conditions (good, fair, and poor) of animals fluctuate with feed shortage in dry seasons. In consistence with this study, Belay

Indigenous fodder trees and shrubs in the study area

In both mid and low altitude areas, fodder trees and shrubs have significant potential to supplement livestock feeds. The available IFTS that are recognized by local farmers are listed in Table 1 below. Similarly, Komwihangilo *et al*. (2001)

Table 1. Identified IFTS with their respective biomass estimated yield

Local name	Scientific Name	Browse type	Mean C	Mean W
Shola	*Ficus sur*	tree	227.4	124.99^{a}
Grawa	*Vernoniya amygadilina*	shrub	99.6	108.97^{ab}
Waak	*Phyllanthus sp.*	shrub	85.3	102.32^{abc}
Gook	*Combretum hartmannianum Schweinf.*	tree	119.6	98.78^{abc}
Chowa / koat	*Tamarindus indica*	tree	161.4	89.12^{bcd}
Nguagn	*Piliostigma thonningii (Schu mach.)*	shrub	77	79.28^{cde}
Wanza	*Cordiya Africana*	tree	137	75.82^{cde}
Mitchol	*Dispoyros sp.*	tree	134.2	74.31^{cdef}
Atat/ Atatish	*Maytenus arbutifolia (A.Rich)wilczek*	shrub	66.6	67.76^{defg}
Sasa	*Albizia gummifera*	tree	117.77	65.3^{defg}
Thow	*Balanites aegyptiaca (L.) Del.*	tree	117.4	65.09^{defg}
Thiep	*Acacia sieberiana DC.*	tree	101	55.96^{efgh}
Esessa	*Albizia schimperiana*	tree	96.38	53.49^{efghi}
Sati(mesengirigna	*Albizia grandibracteata*	tree	85.37	47.35^{fghij}
Bisana	*Croton macrostachyus*	tree	82	45.54^{ghij}
Riak	*Ziziphus pubescens*	tree	79.8	44.29^{ghijk}
Lour	*Acacia nilotica*	tree	79.1	43.87^{ghijk}
Coffee	*Coffeee Arabica*	shrub	36.4	31.51^{hijkl}
Keach	*Ritchiea albersii Gilg*	shrub	35.6	30.6^{hijkl}
Meene	*Saba comorensis (Bo).) Pichon*	tree	54	29.87^{hijkl}
Bow	*Ziziphus spina-christi*	shrub	34.4	29.67^{hijkl}
Alalo \ Alaro	*Acacia seyal Del*	Tree	48.7	26.87^{ijkl}
Chaidock	*Acacia senegal (L.) Wild.*	shrub	28	22.63^{jkl}
Birbira	*Millettia ferruginea*	shrub	26	20.4^{jkl}
Thuer	*Celtis philippensis Blanco*	shrub	22.1	16.39^{kl}
Neet	*Cadaba farinosa Forssk*	shrub	20.9	15.17^{l}
Pour	*Hibiscus calyphyllus*	shrub	19	13.23^{l}

^{a,b,c,d,e,f,g,h,I,j,k}Means with the same letter are not significantly different.

Table 2. Comparison between the biomass yield productivity of low and mid altitude of Gambella region

	Altitude		Browse type		P		
Parameter	Low	Mid	Tree	shrub	Altitude	Browse type	Altitude vs. Browse type
Biomass yield	49.26	64.11	62.71	44.82	*	**	NS

*P<0.05; ** P<0.01; NS= non significant

Table 3. Mean nutritive value (composition %DM) of fodder trees and shrubs collected from low and medium altitude regions of Gambella National Regional state, southwestern Ethiopia

Alt.	Browses	DM	ASH	OM	CP	EE	NDF	ADF	CF	HC	ADL
Low Altitude	*T. indica*	93.62	12.96	87.04	16.52	3.58	53.71	32.05	27.60	21.66	12.10
	A. sieberiana DC.	91.87	12.22	87.78	23.15	2.65	49.62	25.75	22.88	23.87	7.72
	A. nilotica	91.89	9.78	90.22	13.89	2.57	51.76	21.97	20.04	29.79	6.59
	Z. spina-christi	92.39	17.90	82.10	15.03	4.10	27.31	20.20	18.71	7.11	6.06
	A. seyal	93.48	12.02	87.98	21.35	2.55	47.14	34.67	29.57	12.47	10.40
	Z. pubescens	93.13	13.90	86.10	15.64	5.39	62.20	51.17	41.94	11.03	15.35
	B. aegyptiaca	94.47	15.47	84.53	18.81	1.95	48.75	31.59	27.25	17.16	9.48
	A. senegal	91.40	12.91	87.09	22.21	2.11	51.52	36.39	30.85	15.13	10.92
	Dispoyros sp.	94.07	15.64	84.36	13.77	3.12	42.40	31.63	27.29	10.76	9.49
	C. hartmannianum	92.63	8.87	91.13	14.10	8.25	45.21	21.06	19.36	24.15	6.32
	C.farinosa	92.31	11.22	88.78	21.47	3.18	34.87	24.53	21.96	10.34	7.36
	P.thonningii	92.13	13.30	86.70	14.71	2.45	32.58	28.65	25.05	3.93	8.60
	C. philippensis	93.91	12.70	87.30	16.96	2.96	35.69	28.46	24.91	7.23	8.54
	Phyllanthus sp.	88.67	18.67	81.33	14.22	1.68	43.20	26.10	23.14	17.10	7.83
	C. macrostachyus	92.16	13.15	88.85	18.31	3.16	38.96	20.30	18.79	18.66	6.09
Medium Altitude	*M. ferruginea*	94.21	10.16	89.84	23.83	3.12	41.24	37.42	31.63	3.82	11.23
	A. gummifera	91.98	12.01	87.99	19.66	2.40	44.63	38.75	32.62	5.88	11.63
	A.schimperiana	90.67	8.24	91.76	23.34	3.63	37.13	29.20	25.46	7.93	8.76
	V.amygadilina	93.80	8.83	91.17	21.30	2.73	45.23	34.00	29.06	11.23	10.20
	C. macrostachyus	90.42	12.87	87.13	21.10	3.73	38.77	23.55	21.23	15.22	7.07
	A. grandibracteata	92.40	8.71	91.29	23.17	2.87	40.32	32.91	28.25	7.41	9.88
	C. Africana	91.87	10.67	89.33	20.07	3.13	33.45	28.68	25.07	1.91	8.61
	M.s arbutifolia	91.40	12.47	87.53	14.17	3.90	51.40	39.22	32.97	12.18	11.77
	C. Arabica	90.09	9.94	90.06	7.77	2.85	48.80	37.44	31.64	11.36	11.23

DM dry matter, OM, organic matter, CP, crude protein; EE, ether-extract, NDF, neutral detergent fiber; ADF, acid detergent fiber; CF, crude fiber, ADL, acid detergent lignin

shown that most of the goat keepers of semiarid central Tanzania are knowledgeable of the vast resources available in their localities. According to the potential biomass leaf yield production observed in this study, IFTS could be a complement for natural pasture and crop residue shortage for

From the identified IFTS spp. *Ficus sur* and *Vernonia amygdalina* have shown the highest biomass production of trees and shrubs respectively. Whereas *Acacia seyal* and *Hibiscus calyphyllus* have the smallest Production. The biomass productivity of browses at the mid altitude of the region has significantly (P<0.029) higher than the low altitude

Table 4. Nutritive value of browses varied between seasons and altitude regions of Gambella national region, southwestern Ethiopia

	Season		Altitude		Browse type		*P*		
Parameter	Wet	Dry	Low	Mid	Tree	shrub	Season(S)	Altitude(A)	S vs. A
DM	92.93	91.97	92.57	91.9	92.33 [a]	92.2 [a]	NS	NS	NS
ASH	12.76	12.03	13.40	10.71	11.57 [b]	13.99 [a]	NS	**	NS
OM	87.23	88.1	86.60	89.5	88.55 [a]	86.02 [b]	NS	**	NS
CP	18.37	17.97	17.27	19.27	18.64 [a]	16.82 [b]	NS	NS	NS
EE	3.32	3.22	3.33	3.15	3.1 [b]	3.63 [a]	NS	NS	NS
NDF	43.78	43.48	44.71	41.99	45.04 [a]	40.03 [b]	NS	NS	NS
ADF	31.90	30.03	29.58	32.15	32.2 [a]	26.91 [b]	NS	NS	NS
CF	27.49	26.08	25.75	27.67	27.71 [a]	23.74 [b]	NS	NS	NS
HC	13.27	11.88	15.12	9.56	12.68 [a]	13.12 [a]	NS	*	NS
ADL	9.571	9.17	9.054	9.65	9.81 [a]	8.07 [b]	NS	NS	NS

*P<0.05; ** P<0.01; NS= non significant

biomass production of browse species. As indicated above in Table 2 there is high significant difference between the biomass productivity of trees and shrubs of low and mid altitude of Gambella region. Trees have better yield production than shrubs in both agro-ecology. Although there is no interaction effect of altitude and browse type at (P<0.05) on the biomass yield productivity of tree and shrubs of the Gambella region.

Chemical analysis of identified browse species

For the identified fodder trees and shrubs in study area, knowledge of browse production and chemical composition is still lacking. The nutritional composition of foliage's of browse species that are identified during cross-sectional survey through questionnaire and available at both dry and wet season was evaluated and presented in Table 3. The IFTS have shown potential for alleviating some of the feed shortages and nutritional deficiencies experienced in the dry and wet season of the low and mid altitude areas. Similar to this study Simbaya (2002) recognized supplementation of IFTS for small holder ruminant at dry season complement the feeding of crop-residues and natural pastures. According to this study, there is no seasonal and agro ecological difference in nutritive values of the evaluated browses except for ash and OM (P<0.05), higher at low altitude and mid altitude respectively. Higher protein content observed in fodder trees than shrubs (P<0.05). Similarly Yisehak and Janssens 2013, indicated fodder trees showed a significantly higher protein content than fodder shrubs (P<0.05). Higher NDF values of feeds decrease the total feed intake of ruminants and maximum dry matter intake is very important factor in ensuring the release of adequate nutrients for maintenance and production. But in the present evaluated browse species, the NDF values < 45 % revealed high fodder value according to the quality standard described by (Garcia *et al*., 2003). Similarly, the ADF content of the evaluated browses species falls in the excellent to prime quality standard range 31 to 35 % and <31%, respectively. Therefore, based on overall evaluated factors such as biomass production and chemical compositions, the evaluated browse trees and shrubs could be used as potential sources of livestock feed for mid and lowlands of southwest Ethiopia. There is no significant difference (P>0.05) between season and nutrient composition, furthermore there is no agro-ecological and seasonal interaction effect on the evaluated IFTS.

Conclusion

Feed shortage at both wet and dry season reduced livestock productivity. Twenty seven potential fodder trees and shrubs were identified with wide variation of nutrients and biomass productivity. Trees have high biomass productivity than shrubs in general and the biomass productivity of browses is higher at the mid altitude than the low altitude. The high CP and lower NDF content in the IFTS confirms high nutritive value and suitability for supplementation to livestock dependent on natural pasture and crop residue in both wet and dry season. Further works should include developing a systematic usage of IFTS fodder as livestock feed supplement to facilitate the productivity of livestock in the region.

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