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Wheat Production under Mulches of Preceeding *Brachiaria ruziziensis* and *Crotalaria juncea* on Andic Ferrasol of Western Highlands of Cameroon

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Abstract Cultivation of wheat can be extended to non-traditional growing areas through the use of adapted cultivars and relevant crop management practices such as Direct seeding Mulch-based Cropping systems (DMC). DMC are based on the production of high cover crops biomasses in previous agricultural campaigns followed by subsequent crops of interest. This study aimed to assess the biomass production of *Brachiaria ruziziensis*, and *Crotalaria juncea*, in the first agricultural campaign followed by the residual effects of mulch and nitrogenous mineral fertilization on the growth and yield parameters of two subsequent wheat varieties on an andic Ferrasol of the Western Highlands of Cameroon, during the second part of the growing season. Trials were conducted at the Teaching and Research Farm of the University of Dschang in Bansoa in West Cameroon. During the first campaign, biomass production of the two cover crops was assessed in a completely randomized block design with four replicates. This layout was transformed into a split-split-plot design in the second campaign with the mulch of the previous cover crop in main plots, two varieties of wheat in subplots and two levels of nitrogenous mineral fertilization in sub subplots. The amounts of dry matter produced by *B. ruziziensis* and *C. juncea*, were 12.6 and 8.2 t DM ha^{-1}, respectively. The wheat grain yield varied from 1.41 to 3.89 t ha^{-1} during the subsequent agricultural campaign. The effect of preceding crop was significant for plant height, number of spikes, straw and grain yield production. The increase of the number of tillers and spikes due to nitrogen fertilizer application was 20% and 19%, respectively. Results obtained in this exploratory study suggest that wheat can be grown successfully in the Western Highlands of Cameroon under DMC. Further trials involving larger number of varieties, wider range of fertilizer rates and economic assessment would determine the most suitable combinations of factors.

Keywords: *wheat, direct seeding mulch-based cropping system (DMC), cover crops, Brachiaria ruziziensis, Crotalaria juncea, residual effects, wheat fertilization*

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1. Introduction

Expanding wheat (*Triticum aestivum* L.) cultivation into non-traditional wheat areas is a challenge faced by many Sub Saharan African countries [1]. Indeed, wheat is a plant native to temperate regions [2], more specifically from northern Turkey to the Mediterranean regions [3]. This winter cereal which has evolved in temperate environments is being extended to tropical conditions not always favorable for its cultivation [2]. As a result, local production is quite low and tropical countries undertaking such initiative like Cameroon in Central Africa continue to rely on importations to meet their increasing wheat and wheat - product's needs.

The demand for wheat is sustained by a rapid population growth, increased urbanization and change in food habits [1,2,3,4]. A study conducted by the Cameroonian ministry in charge of agriculture between 2011 and 2015 estimated the local consumption of wheat to 24 kg/habitant/year, entirely satisfied by importations [5]. From 377,510 tons in 2010, wheat imports increased to 745,600 tons in 2018 and reached 815,783 tons in 2020. This steady increase of wheat imports is one of the main reasons explaining the need for its local production and justifies the efforts invested to develop wheat domestic production.

A huge potential to expand wheat cultivation into non-traditional wheat areas was recognized founded on the use of adapted cultivars and relevant crop management practices [1]. Previous research works in the tropics reveal average yields of around 2.5 to 5 t ha^{-1} in the Democratic Republic of Congo and Ethiopia [6,7,8], 3 t ha^{-1} in Indonesia [2] and 4 to 5 t ha^{-1} in Nigeria and Pakistan [9,10]. Trials conducted by The Institute of Agricultural Research for Development in Cameroon [11] in various agro–ecological zones of the country have demonstrated a yield potential of 4 t ha^{-1} for four wheat varieties out of the seven tested. In the absence of relevant breeding programmes in Cameroon, more trials are needed in order to identify the most suited varieties for the various agro ecosystems.

Most of the trials conducted so far were under conventional cropping systems. These systems are characterized by extensive use of mineral fertilizers and pesticides combined with regular tillage [12]. Continuous cropping and inadequate replacement of nutrients contained in harvested materials or lost through erosion, runoff and leaching has been the major cause of degradation and drop of soil fertility [13,14]. The depletion of soil nutrients is more acute in densely populated production basins as in the Western Highlands of Cameroon, where strong pressure is exerted on the soil by intensive conventional cropping systems. The end result is heavy loss of soil sediments estimated at 10.4 t ha^{-1} and production potential of soil [15] that can be avoided using appropriate cropping systems such as Direct seeding Mulch-based Cropping systems (DMC).

DMC are presented as alternatives to conventional agriculture and can be used for sustainable soft wheat production [16,17]. These systems promote reduced soil disturbance, permanent soil cover and crop diversification through associations and/or crop rotations [18,19]. The vegetative mulch material can be either dead or alive; it can be produced *ex* or *in situ*, depending upon the purpose [20]. The option often observed in Cameroon is *in situ* mulch with a temporal separation between its production and use [21].

Mulch from the cover crops is strategically located at the soil–atmosphere interface and acts both as soil protector and as soil amendment [20]. Cover crops play several roles in agro ecosystems; in conditions of high rainfall, they improve water infiltration and protect the soil against erosion. Mulch creates favorable conditions for biological activity largely responsible for decomposition, mineralization and release of mineral elements for the benefit of companion or subsequent crops of economic interest [10,22,23]. Overall, the use of cover crop mulching can substantially contribute to obtain higher yields for subsequent crops. The mulch of *Stylosanthes guianensis* decreased by 7.9 t ha^{-1} during the observation period (90 days) with the release of about 3.9 t C ha^{-1} and 104 kg N ha^{-1} in the agro-ecosystem [21].

Cereals such as maize and wheat have been used as subsequent crops to cover crops under DMC [21,24,25]. The nature of the cover crop, the biomass produced and the supply of supplementary fertilization to the subsequent crop are effective in improving the agronomic performance of the system [25,26]. A production of 7.5 t ha^{-1} of biomass was estimated as the minimum for successful implementation of DMC. *Brachiaria ruziziensis* produced up to 20.2 t DM ha^{-1} while 15 t DM ha^{-1} were harvested for *Crotalaria juncea* in the Northern part of Cameroon [26,27]. This exploratory study in the Western Highlands of Cameroon aims to assess the soft wheat production potential under DMC on a Ferrasol with andic character. The objectives of the study are the following: (1) to evaluate the amount of biomass produced in the first agricultural campaign by *B. ruziziensis*, and *C. juncea*; (2) to determine the effect of mulch produced by these cover crops on the growth and yield parameters of two varieties of soft wheat and (3) to determine the effect of nitrogen mineral fertilization on the growth and yield parameters of the two varieties of wheat.

2. Materials and Methods

2.1. Location of the Experimental Area

The experiment was carried out in 2020 at the Faculty of Agronomy and Agricultural Sciences (FASA) Teaching and Research Farm of the University of Dschang in Bansoa, in the West region of Cameroon. The geographical coordinates of the experimental site are as follows: latitude, 5°27’48’’N; longitude, 10°15’30’’E and altitude, 1420 m. The rainfall height during the study period was 1700 mm. The soil is a Ferrasol with an andic character. The soil characteristics determined by the soil analysis laboratory are presented in Table 1.

Table 1. Soil Characteristics of the experimental site

Characteristics of the soil	Values of soil characteristics
Texture (%)	
Sand	74
Silt	17.6
Clay	8.4
Acidity	
pH-water	5.6
pH-KCl	4.9
Organic matter	
Organic carbon (%)	4.00
Organic matter (%)	6.9
Total N (g/kg)	2.94
C/N	14
Exchangeable cations (meq/100g)	
Calcium	14.28
Magnesium	5.28
Potassium	0.49
Sodium	0.47
Sum of cations	21.52
Exchange capacity (meq/100g)	30.40
Available phosphorus Bray II (mg/kg)	26.38

Source: Laboratory of Soil Analysis and Chemistry of Environmental (LSACE), FASA, UDs, 2021.

2.2. Plant Material

Seeds of *B. ruziziensis* and *C. juncea* were obtained from seed producers in the Adamaoua region. Their germination rates were 50% and 95% respectively. The two varieties of soft wheat used were IRAD 1 and BANYO obtained from the Ministry of Agriculture and Rural Development (MINADER). Their germination rates were 97 and 94% respectively. Their potential yield under local growing conditions is 4 to 5 t ha^{-1} and the cropping cycle is about 120 days.

2.3. Treatments

The treatments were combinations of the type of mulch from *B. ruziziensis* or *C. juncea* installed in the first campaign with a control plot without cover crop, two varieties of soft wheat (IRAD 1 and BANYO) installed in the second campaign and two levels of nitrogen fertilization (0 or 100 kg N ha^{-1}) applied to wheat.

2.4. Experimental Design

In the first campaign, a completely randomized block design was laid out to receive the two cover crop species and a control plot without cover crop with four replicates for a total of 12 experimental units. In the second campaign, the experimental design was transformed into a split-split-plot with four replicates. Indeed, the main plots (type of mulch) was subdivided into two levels to receive respectively the wheat varieties (IRAD1 or BANYO) in 6 m x 3 m subplots, and the two levels of nitrogen fertilization (0 or 100 kg N ha^{-1}) in 3 m x 3 m sub-subplots, for a total of 64 experimental units.

2.5. Cultural Practices

The experimental plot was plowed before planting. Cover crops were sown in rows 30 cm apart. The seeding rate was 20 kg per hectare for each species. The seeds, previously mixed with the soil, were distributed along the rows traced to a depth of about 01 cm, then covered with a light thin layer of soil. Cover crops were manually weeded 30 days after sowing. *B. ruziziensis* received 100 kg N ha^{-1}; 100 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1}. *C. juncea* received 50 kg N ha^{-1}; 100 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1}. At the start of the second campaign, a glyphosate-based herbicide at a dose of 100 ml/15 l sprayer was applied to the cover crop. The plots with ordinary fallow cover were cleared to receive the different varieties of wheat.

In the second campaign, wheat was sown at 30 cm x 15 cm spacings with about three seeds per stand for an approximate density of about 1,000,000 plants/ha. The wheat plots received a phosphate and potassium fertilization of 100 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} as recommended for cereals in addition to the two nitrogen experimental levels (0 or 100 kg N ha^{-1}). Fertilizers were applied 14 days after sowing. Wheat plots on ordinary fallow were manually weeded.

2.6. Determination of Aboveground Biomass Produced by Cover Crops

The aboveground biomass produced by the cover crops was collected from quadrats measuring 1.3 m x 0.6 m (0.78 m^2). After harvesting, the biomass was dried successively in the sun and in an oven (70°C) to constant weight to determine the quantities of dry biomass produced.

2.7. Determination of Wheat Growth Parameters

Data were collected from 10 plants in a linear section in the middle of each experimental unit. Plant height was measured at maturity using a tape from the collar to the tip of the spike. The number of tillers was counted on each sampled plant. At maturity, the sampled plants were mowed at ground level. Grains were separated from above ground biomass and the rest weighed to assess straw production.

2.8. Determination of Wheat Yield Parameters

Wheat yield components were determined using counts made directly in the field or from the aerial biomass of the plants sampled. Wheat was harvested when grains reached average moisture content between 12-14%. The spikes were counted per plant and cut using scissors. Harvested plants were mechanically threshed to determine grain yield. The grains obtained were mixed and one batch of 1,000 grains was retained per experimental unit to determine the weight of a thousand grains. The harvest index was obtained by dividing the grain weight by the total weight (weight of straw and grain).

2.9. Data Analysis

The data collected was keyed in and processed on Microsoft's Excel spreadsheet. The analysis of variance was carried out with R software version 4.1.0 at the probability level of 1% for highly significant differences and 5% for significant differences. Mean comparison of statistically different treatments was done using the Least Significant Difference test.

3. Results and Discussion

3.1. Aboveground Biomass Produced by Cover Crops

B. ruziziensis produced a significantly higher amount of biomass compared to *C. juncea* (Table 2). The average biomasses produced over a period of three months were 12.6 and 8.2 t DM ha^{-1} by *B. ruziziensis* and *C. juncea*, respectively. These cover crops may yield higher dry matter biomasses depending on the length of the production cycle and the level of soil fertility [28]. In Northern Cameroon and over a period of one year, a dry aerial biomass of 20 t DM ha^{-1} was recorded for *B. ruziziensis* [27] and 15 t DM ha^{-1} for *C. juncea* [26]. The biomasses recorded in this experiment for the two cover crops within three months are above the threshold value of 7.5 t DM ha^{-1} recommended for entry into DMC in the cotton zone of Cameroon [29]. *B. ruziziensis* could be of higher interest if the challenge is to produce a higher amount of biomass to cover the ground in a shorter period.

Table 2. Dry matter production of *B. ruziziensis* and *C. juncea* during the first part of the growing season and analysis of variance of dry matter data

Dry matter production of *B. ruziziensis* and *C. juncea*					
Cover crops	Dry matter (t DM ha^{-1})				
B. ruziziensis	12.6 ± 0.7				
C. juncea	8.2 ± 1.6				
Analysis of variance					
Source	Df	Sum	Mean square	F	Pr> F
Rep	3	5.47	1.82	1.365	0.4021
Cover crops	1	38.57	38.57	28.895	0.0126 *
Residuals	3	4.00	1.33		

*: Significant at the 5% probability level.

3.2. Plant Height

Wheat plant height varied from 107.5 to 133.5 cm (Table 4) with highly significant differences (P<0.001) depending of the type of mulch (Table 5). The presence of mulch increased plant height by 13 to 15%. Indeed, plants over the mulch of *B. ruziziensis* produced the tallest plants. Similar results were observed under DMC with rice residues [30]. The residual effect of mulches made of *B. ruziziensis* and *C. juncea* favored the growth of subsequent crop by improving the physical and chemical properties of the soil. Higher N-nitrate, N-ammonium and Potassium concentrations were observed under zero tillage compared to ordinary tillage with pea-wheat, canola-wheat and wheat-wheat rotation systems [31]. The significant effect of the cover mulch can be attributed to the mineral fertilizers applied to the previous *B. ruziziensis* and *C. juncea*, the release of mineral elements by the mulch and improvement of nutrient uptake by wheat [17,21,31].

3.3. Numbers of Tillers per Plant

The average number of tillers varied from 3.25 to 5.25 (Table 4). The variety IRAD 1 having received 100 kg N ha^{-1} under mulch of *B. ruziziensis* produced the highest number of tillers (5.25) while the variety BANYO on the control plot without mulch or nitrogen fertilization produced the lowest number of tiller (3.25) (Table 4). Nitrogen fertilization had a highly significant effect (P<0.001) on the number of tillers (Table 5). The application of 100 kg N ha^{-1} to wheat resulted to an increase of 20% of the average number tillers produced per plant. Similar results were obtained in Sudan [32] and Bangladeshi [33]. These results are also similar to those obtained in a trial of mineral nitrogen and potassium fertilization of wheat in Ethiopia where the highest number of tillers was obtained with the application of 69 kg N ha^{-1} [34]. The increase in the number of tillers of wheat varieties with application of N might be due to the role of N in growth and development of plant [35]. The presence of mulch favored an increase of 8 to 14% in the number of tillers due to the potential improvement of physical, chemical and biological properties of the soil after the decomposition of crop residues [36]. Similar results were observed under conservation agriculture where the highest number of wheat tillers was obtained under maize residues 95 days after sowing [37].

3.4. Numbers of Spikes per Plant

The average number of spikes varied from 2.75 to 4.75 (Table 4). The variety IRAD 1 having received 100 kg N ha^{-1} under mulch of *B. ruziziensis* produced a significantly higher average number of spikes (4.75) while the variety BANYO on the control plot without mulch or fertilization nitrogen produced the lowest number of spikes (2.75) (Table 4). The type of mulch had a significant effect (P<0.05) on the number of spikes per plant (Table 5). *B. ruziziensis* mulch produced the highest number of spikes compared to the plot without mulch (Table 3). The presence of mulch led to a 12 to 18% increase in the number of spikes per plant. Mineral nitrogen fertilization had a higher significant effect (P<0.001) on spike formation (Table 5). The treatment that received 100 kg N ha^{-1} produced a significantly higher number of spikes (4.20) compared to the control not fertilized with nitrogen (3.37) (Table 3). The application of nitrogen caused an increase in the number of spikes of 19%. Other studies have also observed an increase of spikes numbers with nitrogen fertilization [38,39]. Nitrogen fertilization favored tillering and the formation of a large number of spikes.

3.5. Wheat Grain Yield

The average wheat grain yield varies from 1.41 to 3.89 t ha^{-1} (Table 4). The variety IRAD 1 having received 100 kg N ha^{-1} under mulch of *B. ruziziensis* produced the highest yield while the variety BANYO not fertilized with nitrogen and on the control plot without mulch produced the lowest yield. Average yields of 3.23 t ha^{-1} and 3.80 t ha^{-1} were obtained in Indonesia and Afghanistan, respectively in a fertilization trial under tropical climatic conditions [2,40]. Similar results were also obtained in Democratic Republic of Congo [6]. Yield varied from 1.10 to 5.71 t ha^{-1} in Ethiopia when nitrogen rates varied from 0 to 360 kg N ha^{-1} [35]. The effect of mulch was highly significant (P<0.001) on grain yield; plots under mulch of *B. ruziziensis* and *C. juncea* produced respectively 3.52 and 2.97 t ha^{-1} while plots without mulch produced an average yield of 1.60 t ha^{-1} (Table 3). The presence of mulch resulted in an increase in grain yield of 46 to 54% compared to the control without mulch. Zero tillage associated with mulch resulted to an increase in wheat yield and the productivity of the system as compared to the conventional system [41]. These results may be attributed to the contribution of residues from the previous cover crops; a wheat yield of 4.8 t ha^{-1} was obtained in DMC involving rice residues in India [10]. The presence of mulch reduced thermal stress, improved soil moisture and therefore the absorption of mineral elements [36,42]. The positive effects on grain yield were also attributed to the decomposition and mineralization of the mulch with a release of nutrients to succeeding plants [21,43].

3.6. Straw

Straw production varied from 3.89 to 10.67 t DM ha^{-1} (Table 4). The variety BANYO not fertilized with nitrogen (0 kg N ha^{-1}) under mulch of *C. juncea* produced more straw (10.67 t DM ha^{-1}) while the variety IRAD 1 on a control plot without mulch and fertilized with nitrogen (100 kg N ha^{-1}) produced less straw (3.89 t DM ha^{-1}). A similar result was obtained in Nepal under rice-rice-wheat rotation [44]. A straw yield of 11.49 t DM ha^{-1} was obtained in DMC under rice residues in India [25]. This experiment reveals a highly significant effect (P<0.001) of mulch on subsequent wheat straw production (Table 6). The presence of mulch favored an increase in straw production of 41 to 45% as compared to the control without cover crop. Decomposition and mineralization of mulch created favorable conditions for biological activities, and improved the nutrients status of soil and the uptake of these elements [16,21,22,26].

3.7. Harvest Index

The harvest index varied from 0.20 to 0.34 (Table 4). There was a highly significant difference (P<0.001) between varieties for harvest index (Table 6). The variety IRAD 1 under mulch of *B. ruziziensis* having received 100 kg N ha^{-1} produced the highest harvest index (0.34) while the variety BANYO under mulch of *C. juncea* without nitrogen fertilization produced the lowest harvest index (0.20) (Table 4). The application of 100 kg N ha^{-1} resulted in a higher harvest index (Table 3). Harvest index was observed to increase with nitrogen fertilizer rate [38].

3.8. Weight of 1000 Grains of Wheat

The weight of 1000 grains varied from 36.5 to 41.2 g (Table 4). The variety IRAD 1 having received 100 kg N ha^{-1} under mulch of *B. ruziziensis* scored the higher weight of 1000 grains. The weight of 1000 grains varied from 32 to 45 g in the long-term rice-rice-wheat rotation in Nepal [44]. There is a highly significant difference (P<0.001) between the two wheat varieties for the weight of 1000 grains (Table 6). In a similar study, the weight of 1000 grains of wheat varied between 39 and 43 g [33]. The weight of 1000 grains of wheat varied from 22.39 to 35.56 g in a varietal trial conducted in the Democratic Republic of Congo [6]. The interaction mulch x N for the weight of 1000 grains is highly significant. The weight of 1000 grains is higher in plots under mulch of *B. ruziziensis* receiving 100 kg N ha^{-1} compared to plots not receiving nitrogen fertilizer; the reverse was observed in plots under mulch of *C. juncea*. The latter being a leguminous crop, the absence of N application did not influence the weight of 1000 grains of wheat.

Table 3. Plant height, number of tillers, number of spikes, grain yield, straw, harvest index and weight of 1000-grains of two soft wheat varieties subsequent to cover crops

Treatment	Plant height (cm)	Number of tillers	Number of spikes	Straw (t DM ha^{-1})	Grain yield (t ha^{-1})	Harvest index	1000 grains weight (g)
				Type of mulch			
B. ruziziensis	131.15a	4.62a	4.12a	9.17a	3.52a	0.30a	38.72a
C. juncea	127.21a	4.31a	3.87ab	8.59a	2.97b	0.25a	38.88a
SPC	110.65b	3.93a	3.37b	5.04b	1.60c	0.25a	38.62a
Varieties							
IRAD 1	122.02a	4.33a	3.91a	6.924a	2.91a	0.30a	39.53a
BANYO	123.98a	4.25a	3.66a	8.283a	2.48a	0.23b	37.95b
Nitrogen fertilization							
0N	124.08a	3.79a	3.37a	7.791a	2.64a	0.25a	39.24a
100N	121.92a	4.79b	4.20b	7.416a	2.76a	0.28a	38.24a

Table 4. Height of plants, number of tillers, number of spikes, grain yield, straw, harvest index and weight of 1000 grains under mulch and doses of nitrogen fertilization

Mulch	Variety	N level	Height of plants (cm)	Number of tillers	Number of Spikes	Straw (t DM ha^{-1})	Grain yield (t. ha^{-1})	Harvest index	weight of 1000 grains (g)
Brachiaria	IRAD 1	0N	130.0±3.8	3.75±0.5	3.75±0.5	8.769±3.4	3.75±0.1	0.31±0.09	38.6±1.6
Brachiaria	IRAD 1	100N	128.5±3.1	5.25±1.5	4.75±0.9	8.115±3.8	3.89±0.4	0.34±0.08	40.3±1.5
Brachiaria	BANYO	0N	132.5±6.0	4.50±1.0	4.00±0.8	9.038±1.7	3.09±0.7	0.25±0.06	37.7±1.0
Brachiaria	BANYO	100N	133.5±11.3	5.00±1.1	4.00±0.8	8.460±3.0	3.34±0.8	0.29±0.10	38.1±2.4
Crotalaria	IRAD 1	0N	131.2±1.6	3.75±0.9	3.50±1.0	7.663±1.0	3.29±0.4	0.29±0.05	41.2±0.5
Crotalaria	IRAD 1	100N	126.8±6.8	5.00±1.1	4.50±0.5	8.248±3.0	3.33±0.9	0.29±0.11	38.9±1.3
Crotalaria	BANYO	0N	127.1± 3.1	3.75±0.5	3.25±0.5	10.677±0.9	2.70±0.3	0.20±0.03	38.8±1.3
Crotalaria	BANYO	100N	123.6± 6.0	4.75±0.5	4.25±0.5	10.101±4.0	2.57±0.3	0.21±0.06	36.5±0.5
WCC*	IRAD 1	0N	108.0± 8.1	3.75±0.5	3.00±0.8	4.850±1.5	1.58±0.4	0.25±0.09	39.4±1.8
WCC	IRAD 1	100N	107.5±14.3	4.50±0.5	4.00±0.8	3.898±1.1	1.61±0.1	0.30±0.06	38.6±0.7
WCC	BANYO	0N	115.6±0.4	3.25±0.5	2.75±0.5	5.750±1.9	1.41±0.3	0.20±0.08	39.5±1.5
WCC	BANYO	100N	111.4±6.9	4.25±0.5	3.75±0.5	5.674±1.7	1.80±0.4	0.24±0.09	36.8±1.6

*; plots without a cover crop.

Table 5. Results of the analysis of variance of plant height data, number of tillers and number of spikes

		Plant height		Number of tillers		Number of spikes	
Sources of variation	DF	F	Pr > F	F	Pr > F	F	Pr > F
Block	3	0.485	0.695	0.713	0.5510	2.059	0.12468
Mulch (MULCH)	2	35.764	0,0000 ***	2.562	0.092384	4.941	0.01327 *
Variety (VAR)	1	0.865	0.865	0.113	0.739296	1.588	0.21642
Nitrogen (N)	1	1.051	0.313	16.218	0.0003 ***	17.647	0.0001 ***
MULCH *VAR	2	1.839	0.175	0.535	0.590673	0.000	1.00000
MULCH *N	2	0.272	0.764	0.084	0.919196	0.706	0.50097
VAR*N	1	0.000	0.983	0.451	0.506763	0.706	0.40686
MULCH *VAR*N	2	0.195	0.824	0.535	0.590673	0.706	0.50097

*: Significant at the 5% probability level, **: significant at the 1% probability level.

Table 6. Results of the analysis of variance of straw yield data, grain yield, Harvest Index and Weight of 1000 grains

		Straw		Grain yield		Harvest index		Weight of 1000 grains	
Sources of variation	DF	F	Pr > F	F	Pr > F	F	Pr > F	F	Pr > F
Block	3	3.63	0.0226 *	3.636	0.0227 *	6.895	0.0009 ***	6.618	0.0012 **
MULCH (MULCH)	2	15.065	0.00002 ***	66.268	0.000 ***	2.595	0.08984	0.193	0.82575
Variety (VAR)	1	4.175	0.0591	9.245	0.0546	10.649	0.00256 **	20.854	0.00006 ***
Nitrogen (N)	1	0.318	0.5768	0.707	0.4064	1.890	0.17850	8.176	0.067
MULCH *VAR	2	0.852	0.4357	2.391	0.1073	0.439	0.64844	1.581	0.220
MULCH *N	2	0.083	0.9201	0.360	0.7003	0.315	0.73211	8.435	0.001 **
VAR*N	1	0.003	0.9586	0.131	0.7197	0.027	0.87155	2.433	0.1283
MULCH *VAR*N	2	0.198	0.8210	0.294	0.7470	0.013	0.98715	0.740	0.48492

*: Significant at the 5% probability level, **: significant at the 1% probability level.

4. Conclusion

The aims of the present exploratory research were to introduce and develop soft wheat cultivation in the Western Highlands of Cameroon through the implementation of Direct seeding Mulch-based Cropping systems (DMC). More specifically, the study assessed the biomass production of two cover crops *B. ruziziensis* and *C. juncea*; the residual effects of the mulches obtained from these cover crops and the effects of two levels of nitrogen mineral fertilization on the performance of soft wheat varieties IRAD 1 and BANYO. *B. ruziziensis* and *C. juncea* produced 12.5 t DM ha^{-1} and 8.2 t DM ha^{-1}, respectively during the first campaign of the cropping season. The quantities of biomass produced within three months were sufficient for the implementation of DMC the subsequent campaign. The wheat grain yield varied from 1.41 to 3.89 t ha^{-1} depending on mulch cover, wheat variety or nitrogen fertilization. The presence of mulch resulted to an increase of 13-15%; 8-14%; 12-18%; 46-54%; 41-45% of plant height, number of tillers, number of spikes, grain and straw yields, respectively, with a highly significant effect (P<0.001) on plant height, number of spikes, grain yield and straw. The effect of nitrogen mineral fertilization was highly significant (P<0.001) for the number of tillers and the number of spikes. The effect of variety was highly significant for harvest index and 1000 grains weight. The variety IRAD 1 obtained a higher weight of 1000 grains (41.2 g) and harvest index (0.34). The results obtained suggest that wheat can be grown successfully in the Western Highlands of Cameroon using proper DMC. Further trials using several varieties for adaptation, a wider range of nutrient doses and an economic assessment are needed to determine the most suitable variety, the optimum level of wheat fertilization, the productivity and profitability at field scale in the study area.

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