Technical report

Up-scaling of annual forage mixtures and enhanced varieties of oat, barley and vetch under CA and conventional systems

1. Research Team

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2. Introduction/Rationale

Nowadays there is a need to reverse natural resource degradation through sustainable crop production intensification which aims to produce more from the same area of land through minimizing soil disturbance;enhancing and maintaining a protective organic cover; cultivating a wider range of plant species; using well-adapted, high-yielding varieties; enhancing crop nutrition; integrating pest and diseases management strategies; adopting efficient water management, using adequate and appropriate farmpower and equipment; and integrating crop-livestock production. These ecologically based management strategies can increase the sustainability of agricultural production while reducing the off-site consequences.

Through first phase of CLCA (2014-2017) and the two first years of CLCA phase II, annual cereal-legume mixtures used for hay of green have emerged as one of the forage options that best fit the need of farmers for quality forage while reducing nutrition cost and sustaining good soil health.They can increase or stabilize crop production and simultaneously provide important agro-ecosystem functions. Up-scaling different forage mixtures at large farm level is mainly hampered by the lack of quality seeds (particularly those of forage legumes), and the need to develop crop mixtures of large and specific environment adaptation.The objective e of this work is to test at on-farm level, agronomic and nutritional potential of several forage mixtures at on-farm level in the aim of up-scaling at the same time to test their adaptation to different environments, agronomic performances, production practicability and ease of use by farmers.

3. Material and methods

3.1. Case study of a Triticale-oat-Vetch mixture under favorable environment: a long term trial

The trial was first sown in 2018 at farm level in Safsafa farm of Abdelkarim Benyoussef, the head of GDAEBN. The mixture partners, their proportions in seeding mix, and management package were continuously discussed and then adjusted in agreement with the farmer, taking into consideration the constraints and counter- performances encountered the year before. In table 1 we report the three management packages (MP) performed.

Table 1. Crop management packages for a common vetch based mixture at on-farm level (Safsafa in NE of Béja)

Item	MP 1	MP 2	MP 3
Year	2018	2019	2020
Area cultivated (ha)	7	6	6
Partners (same varieties)	Oat (30%)-Vetch (70%)	Triticale(20%)-Oat(10%)-Vetch (70%)	Triticale(20%)-Oat(10%)-Vetch (70%)
Total seeding density	300	250	250
Seeding period	November 11th	December 2nd	December 18th
CA	No-till	Minimum tillage	Minimum tillage
Glyphosate before seeding 720 g ai/ha	Yes	Yes	Yes
Simazine (750 g ai/ha) (post seeding-pre-emergeance)	No	No	yes
Nitrogen fertilization	Yes	Yes	No

2. Reinforcing Up-scaling effort through a Public-Private Partnership

During 2020-2021 cropping season, a 3 years renewable agreement was signed between INRAT, CLCA and COTUGRAIN (a seed company) under the supervision of IRESA and by which, CLCA team provides Cotugrainwith the composition of several on-station validated forage cereal–legume mixtures established with the vegetal materiel that cotugrain is routinely commercializing as sole crop (mainly, oat, triticale, fenugreek and common vetch). Accordingly, Cotugrain is required to produce ready-to-sow mixed seeds bags for each crop mixture and to propose them for selling at a studied price. The scientific team is therefore committed to provide a factsheet for crop management of each mixture and to participate in animating farms field days to make them known.The objective behind establishing such an agreement is to ensure seeds availability for crop mixtures, to make farmers more familiar with them and to disrupt the continuous and main constraint hindering their large use by farmers.

The proposed forage crop mixtures are as follows:

Crop mix N°1 : Vetch(70) – Oat(10) – Triticale(20) : (favorable environments)

Species	% in seedingdensity	Seeding density (grains/m²)	Average Thousand grains weight (g)	Seeding rates (kg/ha)
Vetch (cultivar Mghila)	70	175	57,0992	138
Oat (local cultivar)	10	25	27,7042	17
Triticale (cultivar vivacio)	20	50	38,3374	24
Total	100	250		179

Crop mix N°2: Vetch(40) – Fenugreek(30) – Oat(10)-Triticale (20) (large adaptation)

Species	% in seedingdensity	Seeding density (grains/m²)	Average Thousand grains weight (g)	Seeding rates (kg/ha)
Vetch (cultivar Mghila)	40	100	57,1	79
Fenugreek (local cultivar)	30	75	15,4	15
Oat (local cultivar)	10	25	27,7	17
Triticale (cultivar vivacio)	20	50	38,3	24
Total	1	250		135

Crop mix N°3: Vetch (40) —-Triticale (40) : favorable environments

Species	% in seedingdensity	Seeding density (grains/m²)	Average Thousand grains weight (g)	Seeding rates (kg/ha)
Vetch (cultivar Mghila)	60	120	57,1	94
Triticale (cultivar vivacio)	40	100	38,3	49
Total	100	200		143

Crop mix N°4: Vetch (70) – Oat (30) : large adaptation

Species	% in seedingdensity	Seedingdensity (grains/m²)	Average Thousand grains weight (g)	Seeding rates (kg/ha)
Vetch (cultivar Mghila)	70	175	57,1	122
Oat (local cultivar)	30	75	27,7	52
Total	100	250		174

Crop mix N°5: Fenugreek (70) – Triticale (40): semi-arid environments

Species	% in seedingdensity	Seeding density (grains/m²)	Average Thousand grains weight (g)	Seeding rates (kg/ha)
Fenugreek (local cultivar)	70	245	15,4	48
Triticale (cultivar Vivacio)	30	105	38,3	51
Total	100	350		99

Factsheet for crop management of all mixtures (see annexes section) are provided to Cotugrain, INGC personal who are in charge of supervising seeding operation and to some well-advised farmers.

Quantities of forage seeds acquired:

Since CLCA phase II, we have made the choice to specifically grant to farmers only forage seed that are not very available on the market, particularly forage legume seeds, the INRAT newly released varieties etc. The seeds of other staple crops even though those grown in rotation with forage crops are to be covered by the farmer himself.

The quantities of forage seeds acquired through CLCA II during the two last years of the project life are given in table 2. In 2020-2021 cropping season, the total amount of forage seeds acquired doubled as compared to the previous season to better support up-scaling effort of CLCA technologies.

Table 2. Quantities of seeds acquired for up scaling phase (for 2019-2020) cropping season

ėm	2019-2020 cropping season		2020-2021 season	
	Quantity (Ton)	Origin	Quantity (Tons)	Origine
Vetch (cultivar Mghila)	1.2	OEP/INRAT	0.5	OEP/INRAT
Hooded barley (CvLemsi)	0.2	OEP/INRAT	0.2	INRAT
Winter triticale (Cv Our)	0.4	OEP/INRAT	-	
Oat (local cultivar)	1	INRAT	2	INRAT/Bourabia
Common vetch (local cultivar)	2.8	Cotugrain	5	Cotugrain
Mix1	2.5	Cotugrain	-	
Mix2	1.8	Cotugrain	-	
Crop mix 1			2.8	Cotugrain
Crop mix 2			1	Cotugrain
Crop mix 3			2	Cotugrain
Crop mix 4			1.6	Cotugrain
Crop mix 5			0.2	Cotugrain
Total	**8.1**		**15.3**	

During 2020-2021 cropping season, total cultivated area under CA is about 1340 ha (Table 3), spread over 5 governorates and 2 INRAT experimental stations.

Table 3. Details of forage cultivated area through 5 project targeted governorates

Crops	Beja	Kef	Siliana	Zaghouan	Jendouba	Total area (ha)
Vetch	7	8	6	16	0	37
Forage mixtures	13	30	21	26	5	95
Oat	4	5	97	80	0	186
Barley	0	16	79	76	0	171
Lucerne	0	2	0	0	4	06
Sulla	0	0	4	5	0	09
Fenugrec	0	0	0	8	0	08
Wheat	381	17	245	50	4	697
Fababean	6	2	20	0	0	28
Canola	61	0	0	40	0	101
Lathyrus	0	0	0	2	0	02
Total area (ha)	**472**	**80**	**472**	**303**	**13**	1340

At each governorates, a number of fields is assessed for forage yield and quality through sampling 3 x 1 m² quadrate by CLCA team. A survey touching all farmers is to be conducted at the end of the cropping season (next july) to gather all information on real yield, GPS coordinates, cropping conditions and farmer appreciation of the new introduced forages.

4. Main Results

4.1. Results of 2019-2020 cropping seasons (sampling)

The two Cotugrain proposed mixtures (mix1 and mix2, see technical report of 2019-2020) were implemented in different sites under both conventional and CA system. Whatever the site, or cropping

systems (conventional vs CA), both mixtures (mix 1 and mix 2) showed significantly the same average forage yield (about 6 T DM/ha) with greater legume proportion and lesser weed proportion in the four species Mixture than in the binary one.

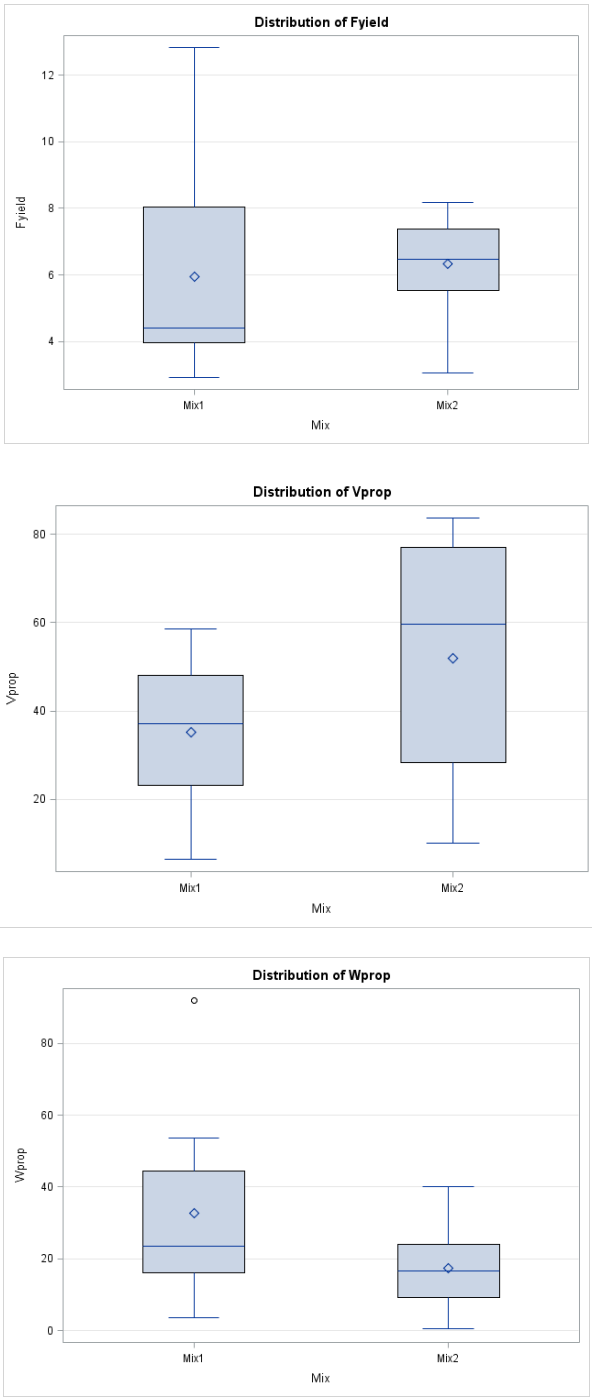

Fig. 1. Average forage yield (Fyield), Vetch proportion (Vprop) and Weed proportion (Wprop) between the two crop mixtures implemented at several sites under conventional or Conservation Agriculture.

4.1. Case study of Vetch-Triticale-Oat mixture at Safsafa site

The agronomic and nutritional characteristics of the common vetch based mixtures conducted under three management packages (table 1) at on-farm level are reported in table 4.

Table 4. Agronomic characteristic of common vetch based mixture under three different crop management packages.

Parameters	MP1	MP2	MP3	SEM	Pr>F
Average forage yield* (T DM/ha)	10.6	14.9	7.35	0.95	>0.0001
Real field yield (bales**/ha)	9	10	6.5	-	-
Vetch proportion	43.7	47.9	59.0	7.23	0.326
Weed proportion	0.05	19.1	0.46	5.51	0.0071
LER	1.01	1.43	1.48	0.08	0.0021
CR	0.66	0.47	0.37	0.04	0.018

*through sampling by CLCA team; **: bales of 30 kg in average ; LER: Leaf area index; CR: competition index of the cereal crop

Both three years were rainy (over 500 mm) particularly in spring season which favored biomass production and global forage yield. ANOVA revealed significant variation of forage yield, weed proportion, LER and CR indexes among the three managing packages.Forage yield was maximum when vetch is crop-mixed with oat (cultivar El Alia that is a high yield late cultivar, MP1) and significantly decreased when oat is partially substituted by Triticale. Lowest yield was obtained with MP3 in 2021, most probably because of the late seeding and the omission of providing Nitrogen in early season. LER was superior to one for all managing packages revealing the advantage of mixing crops rather than growing them each one alone. This advantage reached its maximum under MP2 and MP3 when oats is partially substituted by triticale. Simazine application have proved to be efficient in reducing weed proportion but that is not a guarantee for maximum forage yield. Tutor effect of cereals partners is the most important factor affecting the mixture productivity.

It can be concluded that, the best crop management for common vetch-based mixture includes the simultaneous use of both oat (10%) and triticale (20%) as tutors, mid-late seeding, glyphosate and simazine application prior to seeding and emergence, respectively, and to providing a moderate amount of nitrogen (20 -30 kg/ha) at early season to ensure maximum tutor effect without hampering legume growth.

4.2. Results from 2020-2021 cropping season.

Data are still under process.

5. Outputs

5.1. Website ‘’caf.tn’’

By developing this website, we aim to help farmers and technician to calculate seeding rate of a binary cereal legume mixture, when having the total seeding density, thousand grain weight and proportion of each mixture partners.

Currently, the site is operational and we are aiming to transform it in a friendly smartphone application easy to use for large utilization.

Web Link : http://caf.tn/index.php/fr/

5.2. Factsheets

- The common vetch cultivation (see next page).