EFFECTS OF NON-IRRIGATION CROP ROTATION ON WEED DYNAMICS

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ABSTRACT

Crop rotation is very important with regards to productivity. In fact, the aim of crop rotation is increased productivity. This is achieved by overall benefits of crop rotation, such as better soil quality, reduced pests and weed control by breaking their life cycles. Weed competes with crops for light, nutrients and moisture. The impact of weeds on crop yield varies according to the weed species present, biological characteristic, their density, distribution and their persistence during the cropping cycle. In dry, arid Mongolian condition, due to increased number of mechanical cultivation of soil for controlling weed, soil fertility is decreasing and effected by erosion. Hence, agro-ecosystem is unstabilised. Therefore, for reducing erosion effect and stabilizing agro-ecosystem. So, for those who aim at conserving soil fertility and reducing soil erosion, this is an impelling task to study effects of crop rotation on weed density and diversity, identify and select right predecessor crops for effective weed control.

As a result the determination of weed density before planting in 2, 3 and 4 field rotations revealed more perennial weed infestation of 4 field rotations than 2 and 3 field rotations. Perennial weed population largely composed of ***Agropyron repens, Nonea Pulla, Cirsium Arvense, Potentilla Anserina and Linaria vulgaris****. Fields tend to be increasingly subject to perennial weed infestation as the crop sequence gets lengthier. 21-80 fewer weed plants were found in wheat after fallow (fallow-wheat rotation), compared to 3 and 4 field rotations. Estimated wheat yield was 0.22-0.34 t/ha higher, in contrast to other crop sequences. Weed density in second wheat grown in continuous cropping system gets higher, resulting in reduced yield, which suggests wheat as not ideal pre-crop.*

Keywords: ***crops, weed density, weed species, annual, perennial weed, crop yield***

INTRODUCTION

Crucial agronomic measures for soil conservation include weed control which is often shaped up by different factors including predominant weed species, diversity, density, regional climatic settings, soil properties, crop sequencing, tillage practices, sowing methods and application of herbicides, etc. As earlier researches indicate, weed infestation of crop fields has been major cause of substantial yield loss (not less than 0.2-0.3 t/ha). Weed control measures account for more than 20% of total costs for 3 field rotations, and more than half of the cost of fallow (J. Mijiddorj, 1988). The monocropping of spring wheat across main cropping areas of Mongolia, and an adherence to same production technologies and herbicides over years have resulted in the buildup of annual weed population such as bristle grass (***Seteria viridis L***), common millet (***Panicum milliaceum L***), black bindweed-(***Polygonum convolvulus L***), and ***Fagopyrum tataricum L***, etc, that are well adapted to existing monocropping technology.
The population of weeds in crop fields is never static. Over the years, weeds evolve adaptation to specific conditions, certain crops and the agro-technological measures used in production of

these crops, thriving and spreading their distribution. In short, the weeds have intrinsic ability to adapt to any agro-technological methods.

In a country like Mongolia, with dominant arid, continental climate, increasing intensities of soil tillage for weed control has adverse effects on soil ecology, often resulting in soil erosion, degradation, fertility decline, and unstable agro-ecosystem. So, for those who aim at conserving soil fertility and reducing soil erosion, this is an impelling task to study effects of crop rotation on weed density and diversity, identify and select right predecessor crops for effective weed control.

RESEARCH METHODOLOGY

Place of Study:

The study was conducted in the experiment field for cereal crop rotation at the Agricultural unit of IPAS, in Khongor soum of Darkhan-Uul aimag, in 2016-2019. The main experimental site consisted of 25 randomly selected plots in total, including 8 plots under 2-4 field rotation systems and the rest being the land that lied in fallow for last three decades. The size of one plot is 1260 m^2 /25.2x50 m/. An experiment covers total of 5.2ha area, which is composed of 3.15 ha of cropped area, and 1.87 ha crop free area as a space required for tractor movements in and out of field. A trial of 2-4 field rotation systems that include fallow, grain crops, annual/biannual leguminous and oil plants, was carried out in this experimental field.

Methods for research and analysis:

1. Before sowing crops, the distribution and density of weed population in plots were evaluated by using I.I.Liberstein and A.I.Tulikov's method for defining weed distribution. Number of weed species and weed plants in 0.25m^2, placed on 4 different randomly selected locations within each plot, were counted. Overall weed infestation of plots was rated on 5-point scale, with 1 being least and 5 being critically infested.
2. Following equation was used to evaluate the effectiveness of the herbicides applied on crops in rotation, based on the decline of weeds in quadrant of 1x1m area. Weed plants were counted before and after herbicide application.
   Weed decline = NWAH / NWBH x 100%
   WD-Decline of weed plants, by percentage
   NWAH-Number of weed plants after application of herbicide, weed plants/m2
   NWBH- Number of weed plants before application of herbicide, weed plants/m2
3. Crops and weeds in each experimental plot were sampled during the plants' flowering stage, counted and weighted to determine the percentage of weed biomass (wet) in the crops.

Agro-technical methods used in experimental field:

For the experiment purpose, cereal production technologies, specific to central cropping region, was followed, and the seeds of common grain varieties in central region were used:

1. Darkhan-144 wheat variety was seeded into the seedbed of experimental plot with seeding rate of 3.5 million seeds/ha, at depth of 6 cm, the seeds for wheat in continuous cropping (2^{nd} and 3rd) after fallow, were sown at depth of 6 cm, with the rate of 3.0 million seeds/ha, seeds of oats (var. Rovestnik) and barley (var. Viner) as second and third crops after fallow were sown at depths of 6-8 cm with

rate of 3.5 million and 2.5-3.0 million seeds/ha, respectively, by Omichka SKP-2.1 seed driller, in May 14.

2. Rapeseed (Chinese variety) for seed production, was planted at depth of 2-3cm with seeding rate of 3.0 million seeds/ha, by Omichka SKP-2.1 seed drill, in May 25.
3. Combination of oats and melilot for green manure fallow was planted at depths of 3-4cm, with seed mixing ratio of 30-50kg and 12 kg, respectively. Crops are cut green as fodder by the end of August. Melilot will be used as green manure crop for next summer fallow.
4. Combination of oats (var. Rovestnik) and peas (var. I-20964) was planted at depths of 6-8cm with the rates of 1.0 million and 0.8 million seeds per hectare, by Omichka SKP-2.1 in May 14. All crops are cut green by 5th August for silage, turning the land into occupied fallow.

RESEARCH RESULT

Across our experiment plots, the dominant weed species were: annual weeds such as ***Poligonum convolvulus L***, ***leptopyrum fumariodes***, ***Corispermum declinatum***, ***Panicum Milliaceum***, ***Chenopodium Album L***, ***Kochia scoparia***; biannual weeds such as ***Artemisia Sieversiana wilid***; and perennial weeds including ***Cirsium Arvense***, ***Potentilla Anserina***, ***Agropyron repens***, ***Convolvulus arvensis***, ***Nonea Pulla***, ***Thermopsis Lanceolata***/, ***Linaria vulgaris,*** among others. An estimated loss of yield in an area to which the lowest score or 1 was assigned for being least weed infested, is 0-5% which is insignificant indeed. If weed infestation of cropped area is rated as low or mild (1-2 points on our 5-points scale), the cost of measures taken to control weed population cannot be compensated with value of saved (unlost) yield. If the dominant weed species are largely annual, it is recommended to start taking weed control measures once the annual weed infestation level reaches 3 points on 5-point scale, and 2 points in case of biannual and perennial weeds. An abundance of weed plants per square meter of crops after fallow such as wheat, peas, and rapeseed was erratic, ranging from 24-135 plants, as counted before planting. The dominant weed species were ***Potentilla Anserina***, ***Cirsium Arvense, Nonea Pulla, Agropyron repens, Linaria vulgaris, Convolvulus arvensis*** (all perennials), and ***leptopyrum fumariodes, Kochia scoparia***, and ***Poligonum convolvulus L*** (annual weeds).

Before sowing weed monocultural wheat and double cropping field, per/m^2 /2017/

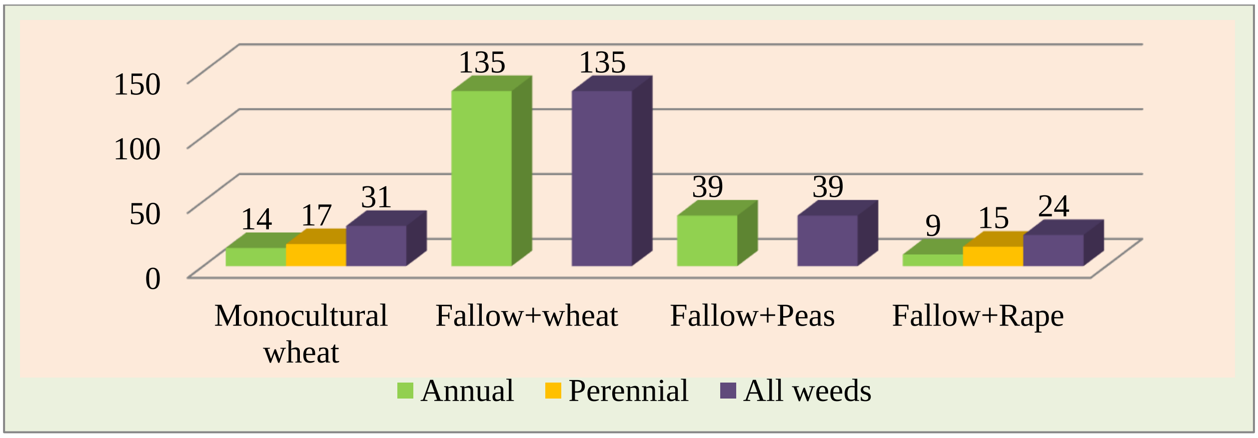
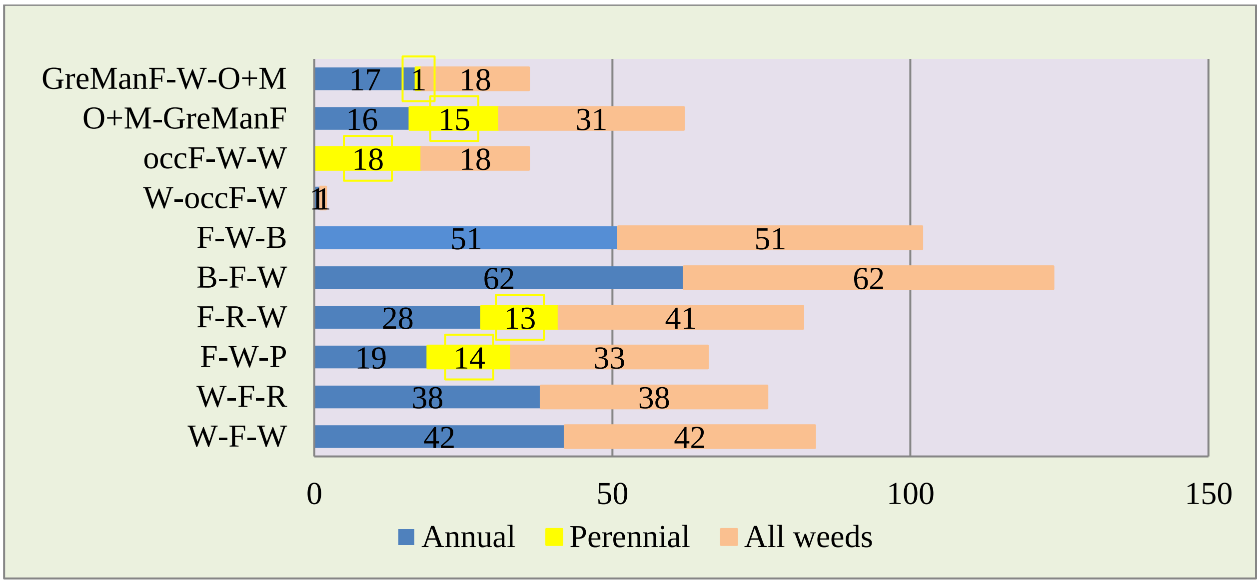


Diagram -1

Weed infestation of some plots, especially those with 135 weed plants, was high, with about 25-35% of plot area covered in weeds. Significantly lower annual weed density was observed on fields of wheat under monoculture and rapeseed, however, 15-17 perennial weeds per square meter is way above the acceptable level of weed infestation.

Before sowing weed 3 field rotation scheme, per/m^2 /2017/



*F-Fallow, W-Wheat, P-Peas, R- Rape, OccF-Occupied fallow, GMF-Green manure fallow, O-Oat, B-Barley, M-Melilot

Diagram -2

Weed density in four different rotations of F-W-W, F-W-B, OccF-W-W, and O+M-GMF-W has been assessed and rated. Abundance of weed was highest in Fallow-Wheat-Wheat rotation, with 62 weed plants per square meter. GMF-W-O+M and OccF-W-W rotations showed very little weed density with around 6-26 weeds per square meter.

Weed diversity in 3 field rotation variants, as shown above, included fewer species of perennial weeds, for example, there was almost no perennial weed species found in green manure and bare fallows.

Before sowing weed 4 field rotation scheme, per/m^2 /2017/

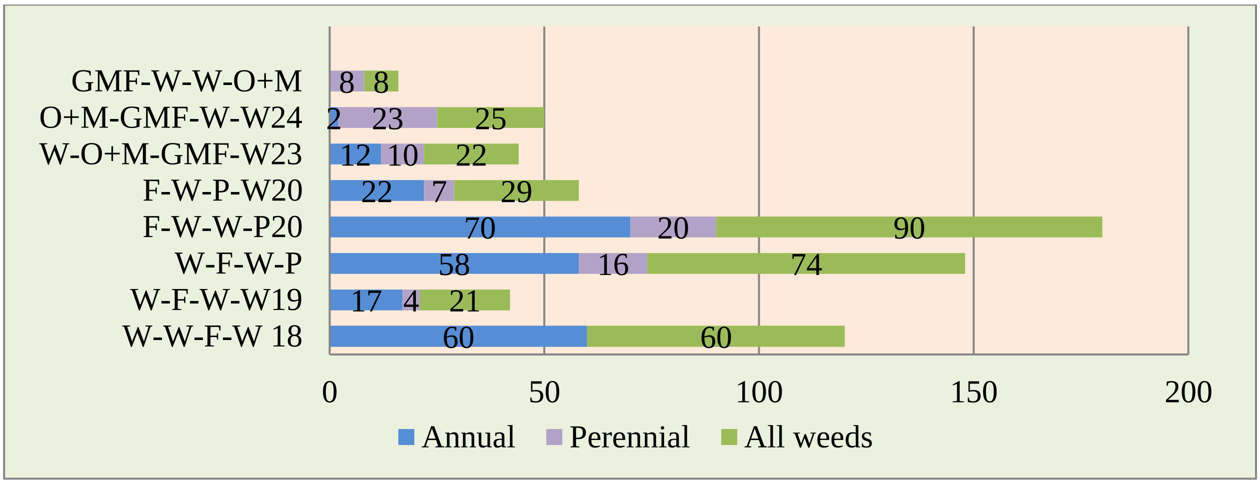


Diagram -3

F-W-W-W and O+M-GMF-W-W rotations show the highest weed density: around 60-90 weed plants in wheat after fallow and peas after wheat (F-W-W-W), and wheat after GMF, as compared to other plots.

The results of the 2017 pre-planting evaluation of weed density in different cropping sequences indicated that four field rotations add to more perennial weeds in the crop, compared to other rotations. Abundance of perennial weeds, as ***Agropyron repens, Nonea Pulla, Cirsium Arvense, Potentilla Anserina, Linaria vulgaris*** in lengthy rotations suggests that longer the cropping sequence, higher the weed infestation. Selection and correct positioning of crops in rotation is a vital tool to control weed population.

Comparative study on weed density in 2-4 field rotations and wheat in continuous cropping revealed two and three field rotations that included rapeseed to be almost free of weeds, which demonstrates excellent competitiveness of rapeseed over weeds. 90.2% and 9.8% of weeds occurring per $1m^2$ of wheat in all evaluated 2-4 field rotations, are annual/biannual and perennial weeds, respectively.

The dominant species are ***Panicum Milliaceum, Poligonum convolvulus L, Chenopodium Album L*** (all annual), ***Artemisia Sieversiana willd*** (biannual), ***Convolvulus arvensis, Linaria vulgaris and Cirsium Arvense*** (perennials). It was also observed that crops become increasingly subject to weed infestation as more crops are put in a single crop sequence, or proportion of wheat in rotation increases. For example: the number of weed plants per square meter in shorter fallow-wheat rotation (2-field rotation) is 8, when compared to 88 and 29 in lengthy and wheat prevailing rotations i.e. O+M-GMF-W-W and F-W-W, respectively, as demonstrated lack of competitiveness of wheat against weeds. In continuous cropping systems, wheat is highly likely to be infested with weeds, as observed during experiment.

Table 1. Influence of crop rotations in weed /*2017*/

Field number	Treatment	Weed, sq/m^2			Weed, g/m^2	Crop dry mass, g/m^2	Percentage of weeds in total biomass
		Annual	Perennial	Total weed			
2	Monocultural	22	-	22	40	167.6	19.30
4	F-W	8	-	8	3.8	282.8	1.3
4	F-R	-	-	-	-	451.6	-
4	F-P	8	-	8	8.8	357.6	2.4
7	W-F-W	6	-	6	2	419.4	0.47
7	W-F-R	-	-	-	-	385.8	-
8	F-W-P	11	12	23	64.2	224.4	22.2
8	F-R-W	7	22	29	23.2	159.6	12.7
10	B-F-W	20	0	20	19.4	591.8	3.17
11	F-W-B	30	4	34	20.4	285.8	6.7
12	W-W-OccF	12	4	16	35.2	366	8.8
13	W-OccF-W	24	8	32	133.8	267.6	33.3
14	OccF-W-W	16	-	16	14	254.8	5.2
16	O+M-GMF-W	6	-	6	9.2	464.2	1.9
17	GMF-W-O+M	18	-	18	51	518.2	8.9
18	W-W-F-W	4	2	6	2.2	527.8	0.4
19	W-F-W-W	28	-	28	50.2	285.4	14.9
19	W-F-W-P	48	-	48	45.4	455.2	9.1
20	F-W-W-P	62	-	62	90.4	204.2	30.7
20	F-W-P-W	88	-	88	114	134	46
23	W-O+M-GMF-W	50	-	50	341	111.8	24.7
24	O+M-GMF-W-W	18	2	20	45.2	259.8	14.8
25	GMF-W-W-O+M	66	-	66	75	319.2	19

Weed infestation of wheat after occupied fallow in 3 field rotations, and peas and wheat in 4 field rotations (F-W-W-P**)** was categorized as severe and critical, respectively, as the determined weed biomass within 3 field rotation was at 30.7-33.3%, with 46.0% in 4 field rotations (F-W-P-W).

Table 2. Influence of weed in wheat yield, t/ha /2017/

Rotation types	Germination, *sq/m²*	*Seed yield, t/ha*	Weed, *sq/m²*
Monocultural wheat	37.5	0.657	22
Fallow-Wheat	**39**	**1.27**	**8**
Wheat – Fallow- Wheat	41.7	1.35	6
Fallow- Wheat – Wheat	**61.3**	**1.05**	**29**
Barley- Fallow- Wheat	57.85	1.39	20
Fallow- Wheat - Barley	41.66	0.599	34
W-OccF-W	43.28	0.967	32
OccF-W-W	51.16	0.939	16
O+M-GMF-W	46.42	1.057	6
W-W-F-W	57.17	1.604	6
W-F-W-W	42.83	1.235	28
F-W-W-W	**43.33**	**0.933**	**88**
W-O+M-GMF-W	55.71	1.185	50
O+M-GMF-W-W	57.66	1.115	20

An estimated yield of wheat grown in fallow-wheat cropping sequence (2 field rotations) was 1.27 t/ha when number of weed plants per square meter of wheat field was 8. Significant wheat yield drop and higher weed infestation are seen in 3 and 4 field rotations in which wheat is grown in continuous cropping systems: Fallow-Wheat-Wheat and Fallow-Wheat-Wheat-Wheat. Estimated yields and weed density in said rotations are 1.05 t/ha, 29 weeds per/m^2, and 9.33 t/ha, 88 weeds per/m^2, respectively. The table provides clear evidence for implicit association between yield, weed infestation and continuous cropping of wheat.

The positive effects of fallowing on crop yield can be seen from fallow-wheat rotation, which, in contrast to 3-4 field rotations, produces 0.22-0.34 t/ha more wheat, and bears 21-80 fewer weed plants. The table also provides higher weed density in each plot under succession cropping (as revealed by number of weeds per 1m^2), mainly resulted from hefty showers in late summer. It needs to be highlighted that most of the counted weed plants on fields were indeed newly emerged weed sprouts. Starting from second 10 days of July, young weeds began to emerge in numbers on fields that were virtually free from weeds after herbicide application. Yield of wheat grown after fallows (green manure fallow, occupied fallow and bare fallow) was high enough at 0.27-1.60 t/ha, when compared to wheat in continuous cropping system, and/or barley after wheat.

CONCLUSION

1. Annual/biannual and perennial weeds account for respectively 90.2% and 9.8% of all weeds occurring in numbers, ranging from 6 to 88, per meter square area of evaluated 2-4 field rotations. The dominant species in experiment fields were ***Poligonum convolvulus L, Leptopyrum fumariodes***, ***Corispermum declinatum***, ***Panicum Milliaceum***, ***Chenopodium Album L***, ***Kochia scoparia*** (all annual weeds)***, Artemisia Sieversiana willd*** (biannual weed), ***Cirsium Arvense***, ***Potentilla Anserina***/, ***Agropyron***

repens, ***Convolvulus arvensis***, ***Nonea Pulla***, ***Thermopsis Lanceolata***, and ***Linaria vulgaris***/ (all perennial weeds).

2. The determination of weed density before planting in 2, 3 and 4 field rotations revealed more perennial weed infestation of 4 field rotations than 2 and 3 field rotations. Perennial weed population largely composed of ***Agropyron repens, Nonea Pulla, Cirsium Arvense, Potentilla Anserina and Linaria vulgaris***. Fields tend to be increasingly subject to perennial weed infestation as the crop sequence gets lengthier.
3. Determination of weed biomass during flowering stage in rapeseed grown in 2-3 field rotations revealed zero weeds. Rapeseed has excellent competitiveness against weed growth.

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BRIEF INTRODUCTION OF THE AUTHOR

Saikhantsetseg Sosorbaram graduated from Mongolian University of Life Sciences in 1997 and majored in Agronomy. In 2000, I received master's degree in "Sowing period influence of yield for spring wheat", in 2014 completed Ph.D's thesis on "Possibility to use no tillage and straw mulch technologies for fallow and cereal rotation in central cropping zone of Mongolia" Since 1997 I have worked as a researcher at the crop farming division of Institute of Plant and Agricultural Sciences. I'm working in the field of soil cultivation, crop rotation and weed control.