IMPACT OF SOIL STERILIZATION FROM DIFFERENT LOCATIONS, WHEAT SEEDS CLEANING AND THEIR INTERACTIONS ON WEED CONTROL, AND YIELD AND YIELD COMPONENTS

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ABSTRACT

A factorial pots experiment (2x2x4) was carried out using completely randomized design (CRD) with three replications, in Qlyasan Research Station / College of Agricultural Engineering Sciences / University of Sulaimani during Nov.25,2018 and Jun.2,2019, to determine the effects of seed bank sterilization, wheat seed cleaning and soil of different four locations and their interactions on weed control, yield of bread wheat *Triticum aestivum* L. (var. Adana) and yield components. The first factor was wheat seeds, machinery cleaned seeds (A1) and non-cleaned seeds (A2), the second factor was soil sterilization: sterilized soil (S1) and non-sterilized soil (S2), while the third factor was soils from four different locations: Qlyasan (L1), Kani Panka (L2), Halabja (L3) and Chamchamal (L4). Results showed that machinery seed cleaning decreased weed dry weight (WDW), and increased number of spikes (NS), total spikes weight (TSW), and grain yield (GY). Soil sterilization decreased WDW and increased plant height (PH), NS, TSW, and grain yield. L2and L4 recorded the lowest WDW, and L2 recorded the highest NS, TSW and GY. Interaction treatment A1S1decreased WDW and increased PH, NS, TSW and GY. Interaction treatment A1L2 decreased WDW and increased NS, TSW and GY. Interaction treatment S1L2 decreased WDW and increased NS, TSW and GY. Triple interaction A1S1L2 decreased WDW and increased NS, TSW and GY significantly.

Key words: weed management, seed purity, soil sterilization, wheat,grain yield.

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تأثير تعقيم ترب من مناطق مختلفة و تنظيف البذور في مكافحة الأدغال و حاصل الحنطة و مكوناته

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المستخلص :

نفذت تجربة عاملية خلال تشرين الثاني/2018 و حزيران 2019 بأستعمال سنادين بثلاث عوامل و ثلاث مكررات لكل عامل, في محطة الأبحاث الزراعية في قلياسان التابعة لكلية الزراعة /جامعة السليمانية /أقليم كردستان العراق, طبقت التجربة وفق التصميم العشوائي الكامل لتحديد تأثير تنظيف البذور و تعقيم تربة جلبت من اربعة مناطق مختلفة على فعالية مكافحة الأدغال وانتاجية ومكونات حاصل الحنطة, العامل الأول: تنظيف البذور بمستويين (بذور منظفة A1و بذور غير منظفةA2) والعامل الثاني تعقيم التربة وهي ايضا بمستويين (تربة معقمةS1 و تربة غير معقمةS2) أما العامل الثالث فكان ترب من أربعة مناطق مختلفة وهي: قلياسان, كاني بانكه, حلبجة, جمجمال. أظهرت النتائج ان تنظيف البذوربالمكائن خفض من الوزن الجاف للأدغال ورفع كل من عدد السنابل والوزن الكلي للسنابل وحاصل الحبوب . كذلك بينت النتائج ان معاملة تربة كاني بانكه وجمجمال سجلت اقل وزن جاف للأدغال, بينما تربة كاني بانكه حققت أعلى عدد للسنابل وأكبر وزن كلي للسنابل مع أعلى حاصل حبوب. تأثير التداخل بين الحبوب المنظفة مع تربة كاني بانكه كان معنويا, اذ خفض الوزن الجاف للأدغال و سبب زيادة في عدد السنابل والوزن الكلي للسنابل وكذلك حاصل الحبوب, أيضا كان التداخل معنويا بين تعقيم التربة و نوع التربة من كاني بانكه, اذ سجلت خفضا في الوزن الجاف للأدغال مقابل زيادة في عدد السنابل والوزن الكلي للسنابل و حاصل الحبوب. كان للتداخل الثلاثي بين معاملة تنظيف البذور وتعقيم التربة مع أستعمال تربة من كاني بانكه تأثيرا معنويا في خفض الوزن الجاف للأدغال و زيادة في عدد السنابل والوزن الكلي للسنابل وكذلك حاصل الحبوب.

الكلمات المفتاحية: تربة معقمة, بذور منظفة, حاصل الحبوب, وزن جاف للأدغال, وزن السنابل

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INTRODUCTION

Weeds are a perennial problem with the farmers; they are considered one of the important factors limits crop production. Weeds are widely spread and reduce yield of crops considerably. Weeds also lower crop quality, it may reduce the protein content of the grain (34). Among the biotic factors weeds are one of the major constraints in wheat production as they reduce productivity due to competition, allelopathy and by providing proper habitats for pathogens as well as serving as alternate host for various insects, fungi and increase harvest cost (7). Farmers spend a lot of resources to reduce weeds impact, many a times quite unsuccessfully (ISWS, 2018). It is estimated that loses caused by weeds for wheat production ranges between 29 to 31% (37, 21) while other studies mentioned that this figure may reach to 65% (5).Weed control is becoming harder due to economic expenses; the elevating herbicidal prices; higher yields demanding; economic and political factors. Unethical use of herbicides causes serious damaging not only to the crop but even to the agro-environment. Frequent using of herbicides produce weed resistance to herbicides, therefore to minimize this problem and for efficient weed management, the non-chemical weed management tactics or by reducing herbicide applications such as cleaned or weed-free cultivated seeds should be adopted in conjunction with chemicals (like herbicide mixture and rotation, optimum spray time, dose and methods) (15, 36) or through minimizing herbicides amount . Some of the non-chemical agronomic strategies like tillage, sowing time and methods, competitive crop cultivars, higher crop density (8, 9), crop rotation and sanitation practices (weed-free crop seeds and seed cleaning) can be adjusted and adopted in such a manner that they provide the competitive edge to the crop over weeds (38, 22, 33). Several studies have found that cleaning the seeds reduces the return of weed seeds to the soil and increases wheat grain yield (31, 12, 36, 50). Soil contains many weed seeds from previous years seeding and this is known as the ‘seedbank’. Thompson and Grime (48) defined the seed bank as "all the detached viable seeds of a species at a specific time, and includes seeds present both above and below the soil surface". understanding the seedbank is at the heart of effective weed management, therefore the soil seedbank has been called the memory of the land. Weed seedbanks may be used to monitor the success of long term weed control programs, and a knowledge of the species composition of the seedbank may give some guidance on the choice of future weed management strategies (43). Benvenuti et al. (10) found that most of the viable weed seeds are near the soil surface, and that means more competition with wheat crop roots. In their study on the effect of soil sterilization on improving crop growth and yield in wheat, Javaid et al. (25) ,found that plant vegetative and reproductive growth and grain yield was better in heat-sterilized than in nonsterilized soil. In a study of effect of soil sterilization with steam on weed seeds by Castillo-Luna and Gómez-Gómez (13) it was found that soil sterilization method was effective in eliminating the viability of three evaluated weed seed species. In their study Nishimura et al. (35) mentioned that steam application is an effective method for controlling weed seed infestation. This study aims to determine the effect of seed cleaning on wheat crop yield and yield components, moreover find the effect of seed bank capacity on weed control process and wheat production.

MATERIALS AND METHODS

A factorial experiment carried out in pots in a completely randomized design (CRD) with three replications for each treatment, applied during Nov.25,2018 and Jun.2,2019 in Qlyasan Research Station / College of Agricultural Engineering Sciences / University of Sulaimani (coordination 35o.34’18” N 45o.22’ 01” E with altitude of 749 meters above sea level).The experiment consists of three factors (2x2x4), the first factor was wheat seeds Adana variety, of two levels; cleaned seeds (A1) (seeds cleaned by seed cleaning machines) and non-cleaned seeds (A2), the second factor was soil sterilization in two levels: sterilized (S1) and non-sterilized soils(S2) and the third factor was soils from four different locations: Qlyasan (L1), Kanipanka (L2), Halabja (L3) and Chamchamal(L4).

Cleaning and sowing wheat seeds:

Wheat seeds (var. Adana) were collected from the fields of College of Agricultural Engineering Sciences, harvested by the combine harvester during June 2018. Those seeds were divided into two parts; the first part was used in this study as clean seeds (A1) which was cleaned by the seed cleaning machine to get rid of any weed seeds, infested wheat seeds by insects or fungus, debris, dirt dust, immature seeds, empty seeds, shrunken seeds, discolored seeds and peeled or broken seeds. while the second part non-clean seeds (A2) were the harvested wheat seeds by the combine harvester without cleaning.

Soil samples and analysis: Soil samples of the four experimental locations: were taken using auger at depth of 0-30 cm from the soil surface. Subsamples taken from Qlyasan location were mixed carefully, then a representative sample of 5 kg soil free from plant roots and other debris, air dried gently crushed and sieved using 2 mm with a stainless steel sieve, was taken for physical and chemical analysis. The same process was done for the soil samples of other three locations (Kanipanka, Halabja and Chamchamal). Particle size distribution for textural class assessing was carried out by international pipette method as described by Black et al. (11). Hydrogen ion concentration (pH) and electrical conductivity (EC) in a suspension ratio of 1:10, soil to H_2O as determined by Thomas (47) , using pH model of WTW 330i, whereas for EC the model WTW 330i EC-meter was used. Organic matter percentage (O.M.%) were determined by wet oxidation method according to Walkley-Black method (11). Organic Matter O.M. % was calculated according to the following equation:

O.M. % = Organic carbon% × 1.724 (factor).

Calcium carbonate $CaCO_3$% (g kg^{-1}) was determined according to a 23C method of U.S. salinity laboratory staff, 1954, as mentioned in Black et al.(11) (Table 1)

Table 1. Physical and chemical properties of the soil samples for experimental locations (Kanipanka, Qlyasan, Halabja and Chamchamal)

Physicochemical properties		Soil samples from different locations			
		Kani Panka	Qlyasan	Halabja	Chamchamal
Particles size distribution (g kg^{1})	Sand	36	107	80	106
	Silt	529	435	403	538
	Clay	435	458	517	356
	Texture	Silty Clay	Silty Clay	Silty Clay	Silty Clay
PH		7.70	7.59	7.21	7.62
ECe (micro siemens cm^{-1}) or (µS cm^{-1})		218	490	320	520
O.M. (g kg^{-1})		22.4	14.8	19.6	15
CaCO3 (g kg^{-1})		208.3	304.3	230	321

Soil sterilization: Soil of each location was divided in to two parts, the first part was used without sterilization, as non-sterilized soil and the second part was steam sterilized by putting the soil sample in a canvas bag, the bag was placed in an aluminum foil then it was put in the autoclave for one hour under 121 ^{0}C and 15 psi to kill any preexisting weed seeds and root system parts in the soil (weeds propagules), the procedure was repeated three times for each soil sample (after samples were cooled) , to ensure that heat will reach any weed seeds even the dormant seeds and kill it.

Pots dimensions: Uniform plastic pots were used, 24 cm depth and 25 cm diameter, with holes in the bottom for drain, and each pot was loaded with 6 liters of soil, three replications of each treatment was prepared.

Wheat seeds sowing in pots

Wheat seeds (Var. Adana) was used in the present experiment; seeds were divided into two parts, cleaned seeds and non-cleaned seeds as factor number one. On 25th November, 2018 wheat seeds were sown in the pots at a rate of 120kg.ha^{-1}, each pot surface area was 0.05 m^2, accordingly the amount of seeds sawn was 0.6 g/pot of cleaned seeds and non-cleaned seeds (for the cleaned seeds it was found that 0.6g contains 15 seeds, but for non-cleaned seeds the weight measurement was not

used in order to keep the original distribution (type and amount of weed seeds). Pots were placed at the field ground at the depth of 10cm to ensure that soil moisture will be maintained from the ground, pots were randomly distributed in the land of Qlyasan according to CRD. Pots were irrigated when it was needed. Cultural practices were conducted normally including fertilizing with di-ammonium phosphate (DAP 18-46) which applied to all treatments with cultivation, in a dose of 174 Kg ha^{-1}, while urea (46% N) was applied in a dose of 106 Kg ha^{-1}, divided in to two parts, the first part was applied in tillering stage and the second application was in booting stage for both location

Wheat harvest: On June 1st, 2019 Qlyasan experiment pots were harvested, all plants (wheat and weeds) were harvested manually by cutting it above ground and kept in labeled plastic bags. in the lab wheat plants were separated from weeds, as relative humidity is very low during harvest time no additional drying was required (table 2), weeds dry weight of each pot was calculated, obtained dry weights were expressed in $g.pot^{-1}$, and the following parameters were registered for all harvested wheat plants:

Plant height (cm): Ten wheat plants height were recorded with the help of meter scale from base of plants to the tip of the spikes, averaged and expressed in cm.

Number of spikes. pot^{-1}

Wheat spikes were counted in each harvested pot.

Total spikes weight. pot^{-1}

weight of all spikes in each harvested pot of all treatments was calculated.

Grain yield. pot^{-1}: All wheat spikes of each harvested pot were thrashed manually; grains were separated from straw and weighted.

Statistical analysis: Data of the experiment were analyzed statistically using XLSTAT 2016 and the means of treatments and interactions were compared according to revised LSD at the level of 0.05 of significance

Table 2. monthly temperature and precipitation for Qlyasan research station for the season 2018-2019

		Qlyasan			
	Months	Min. Temp. (^{0}C)	Max. Temp. (^{0}C)	Avg. Temp. (^{0}C)	Rainfall (mm)
2018	*October*	10.8	36	23.4	41.5
	November	5	25.9	15.4	101
	December	2.3	18	10.1	324
2019	*January*	-2.5	15	6,3	152
	February	1.5	17	9.2	135
	March	1.6	19.5	10.2	266
	April	5.5	26	15.7	177
	May	10.4	36	23.2	44
	June	21.6	42	31.8	4.5
		Total rainfall			1245

RESULT AND DISCUSSION

Effect of cleaning wheat seeds, soil sterilization of different locations and their interactions on dry weight of companion weeds pot^{-1} (WCW/P) (g).

Effect of cleaning wheat seeds

Results in table 3 show the significant effect of different treatments on weed dry weight (WDW). Cleaned wheat seeds reduced WDW significantly (2.513 g) compared to non-cleaned seeds (9.213 g), this result was in harmony to what mentioned by Hossain (22) and Hussain et al. (23) that seed cleaning is effective in minimizing weeds. Cleaning of wheat seeds before sowing was effective in reducing weed dry weight by 72% and results agreed to what reported by Norsworthy et al. (36) and Owen and Powles (38) who found that using of cleaned seeds is an effective method to control weeds.

Effect of soil sterilization:

Soil sterilization showed a significant effect on minimizing WDW (Table 3); sterilized soils

reduced WDW significantly to 3.3192g (60%) compared to unsterilized soils (8.4078g).

Effect of soils from different locations

Soils of L2, L3 and L4 reduced WDW significantly to 5.6161, 5.6287 and 5.3078g respectively compared to the soil of L1 which registered 6.901g (table 3). It seems that the soil of Qlyasan containing a lot of weed seeds.

Effect of interaction treatments:

There are significant difference effects of the interactions between wheat seed cleaning, soil sterilization and soils of different locations on WDW (Table 3). The interaction between seed cleaning and soil sterilization (A_1S_1) showed a significant reduction in WDW (0.24107g) compared to Non-cleaned seeds unsterilized soils (A_2S_2) which registered the highest WDW (12.0298 g). Interaction treatments A_1L_2, $A_1L_3$and A_1L_4 reduced WDW significantly compared to A_2L_1, A_2L_2, A_2L_3 and A_2L_4). Interaction treatments S_1L_1, S_1L_2 and S_1L_4 also reduced WDW significantly compare to S_2L_1 which record 10.712 g. The triple interaction treatments $A_1S_1L_1$, $A_1S_1L_2$, $A_1S_1L_3$and $A_1S_1L_4$ all reduced WDW significantly compared to $A_2S_2L_1$ and $A_2S_2L_2$ which recorded 13.5510 and 14.2036g respectively. the combined effect (synergism) of seed cleaning and soil sterilization which both work to minimize weeds, the seed cleaning eliminates any weed seeds to be sown, in addition, it resulted to produce high vigour seed which tend to be more similar in shape and size, reflecting on the accuracy of the number of plants area^{-1} (26, 18) , on the other hand soil sterilization have killed any weed seeds or propagules that were in the soil to the depth of 25cm ,as a part of the soil seed bank (25, 29)

Table 3. Effects of cleaning wheat seeds, soil sterilization of different locations, and their interactions on weeds dry weight pot^{-1}(g).

Seed cleaning (A)	Soil sterilization (S)	Soil from different Locations (L)				Seed cleaning * Soil sterilization (A*S)
		Qlyasan (L1)	Kani Panka (L2)	Halabja (L3)	Chamchamal (L4)	
Cleaned seeds (A1)	Sterilized soil (S1)	0.64403 h	0.32006 h	0.00010 h	0.00010 h	0.24107 d
	Unsterilized soil (S2)	7.87400 d	3.58433 g	3.71733 g	3.96766 g	4.78583 c
Not Cleaned seeds (A2)	Sterilized soil (S1)	5.53666 ef	4.35666 fg	9.57000 c	6.12666 e	6.39750 b
	Unsterilized soil (S2)	13.5510 a	14.2036 a	9.22766 cd	11.1370 b	12.0298 a
	A1	4.259 b	1.952 c	1.858 c	1.983 c	2.5134 b
	A2	9.543 a	9.280 a	9.398 a	8.631 a	9.2136 a
	S1	3.0903 e	2.3383 e	4.7850 d	3.0633 e	3.3192 b
	S2	10.712 a	8.8940 b	6.4725 c	7.5523 c	8.4078 a
	L Mean	6.9014 a	5.6161 b	5.6287 b	5.3078 b	

LSD 0.05 values for A = 0.541, S = 0.541, L = 0.765, A*S = 0.7659, A*L= 1.083, S*L = 1.083, A*S*L = 1.5317

Effect of cleaning wheat seeds, soil sterilization of different locations and their interactions on wheat plant height (WPH)

Effect of cleaning wheat seeds

Table 4 shows no significant differences between the treatments of seed cleaning and un-cleaned seeds in their effects on the wheat plant heights (WPH).

Effect of soil sterilization

Soil sterilization caused significant increases in WPH (69.533cm) compared to non-sterilized soils which recorded 61.641cm (Table 4). The results are in compatible with the results obtained by Dietrich et al.,(19) using steam sterilization which increased phosphorus concentration causing root strengthen and deep extension to support the plant by soil moisture and nutrients (16, 17, 44).

Effect of soils of different locations

Results of table 4 illustrate that soils of L1 and L2 increased WPH significantly to 68.7833 and 66.0666 cm respectively compared to soils of L3 and L4 which recorded 64.3333 and 63.1666 cm respectively.

Table 4. Effects of cleaning wheat seeds, soil sterilization of different locations, and their interactions on wheat plant height pot^{-1}(cm).

Seed cleaning (A)	Soil sterilization (S)	Soil from different Locations (L) Qlyasan (L1)	Kani Panka (L2)	Halabja (L3)	Chamchamal (L4)	Seed cleaning * Soil sterilization (A*S)
Cleaned seeds (A1)	Sterilized soil (S1)	75.666 ab	72.266 abc	65.666 cdef	63.3333 def	69.233 a
	Unsterilized soil (S2)	58.133 f	60.333 ef	67.333 bcde	60.666 ef	61.616 b
Not Cleaned seeds (A2)	Sterilized soil (S1)	78.666 a	71.333 abcd	65.666 cdef	63.666 cdef	69.833 a
	Unsterilized soil (S2)	62.666 def	60.333 ef	58.666 f	65.000 cdef	61.666 b
	A1	66.900 ab	66.300 ab	66.500 ab	62.00 b	65.4250 a
	A2	70.666 a	65.833 ab	62.166 b	64.333 b	65.7500 a
	S1	77.166 a	71.800 ab	65.666 bc	63.500 c	69.533 a
	S2	60.40 c	60.33 c	63.000 c	62.83 c	61.641 b
	L Mean	68.7833 a	66.0666 ab	64.3333 b	63.1666 b	

LSD values 0.05 L = 4.3657, A = 3.0870, S = 3.0870, A*S = 4.3658, L*A = 6.1741, L*S = 6.1741, A*S*L = 8.6662

Effect of interaction treatments

Interaction treatments $A_1S_1$and A_2S_1 caused significant increases in WPH (69.233 and 69.833 cm respectively) compared to A_1S_2 and A_2S_2 (61.616 and 61.666 cm respectively), Interaction treatments A_2L_1 also caused the largest increase in WPH significantly (70.666cm) compared to A_1L_4, A_2L_3 and A2L4 (62.00, 62.166 and 64.333 cm respectively) and S_1L_1 and S_1L_2 increased WPH significantly (77.166 and 71.800 cm respectively) compared to S_1L_4, S_2L_1, S_2L_2, S_2L_3 and S_2L_4 which recorded 63.500, 60.40, 60.33, 63.00 and 62.83 cm respectively. The triple interaction treatment $A_2S_1L_1$ increased WPH significantly to 78.666cm compared to $A_2S_2L_3$ (58.666cm). Effects of soil sterilization is clear on increasing the WPH, that is may be due to the effects of heating on the availability of nutrient elements in the sterilized soils, specially phosphorus concentrations as explained by Dietrich et al. (19).

Effect of cleaning wheat seeds, soil sterilization of different locations and their interactions on number of spikes pot^{-1}(NS/P). : Number of spikes. area^{-1} is one of the important trait contributing to the grain yield in wheat (6).

Effect of cleaning wheat seeds

Cleaned seed treatments increased number of spikes.pot^{-1} significantly (NS/P) to 22.041 spikes compared to non-cleaned seeds (17.125 spikes), that is may be due to decrease in weed seeds, therefore less weed seedlings, allowing wheat plants to grow freely because there is no competition with weed plants. These results are in compatible with the results obtained by Tibola et al.(49) ; Lollato,(30) ; and also what found by Al-Chalabi (2) and De Lucas Bueno and Froud Williams (18).

Table 5. Effects of cleaning wheat seeds, soil sterilization of different locations, and their interactions on the number of spikes pot^{-1}

Seed cleaning (A)	Soil sterilization (S)	Soil from different Locations (L) Qlyasan (L1)	Kani Panka (L2)	Halabja (L3)	Chamchamal (L4)	Seed cleaning * Soil sterilization (A*S)
Cleaned seeds (A1)	Sterilized soil (S1)	27.666 b	32.666 a	24.333 bc	27.000 b	27.916 a
	Unsterilized soil (S2)	14.666 de	15.333 de	18.333 d	16.333 de	16.166 c
Not Cleaned seeds (A2)	Sterilized soil (S1)	23.000 c	27.000 b	24.000 bc	17.333 de	22.833 b
	Unsterilized soil (S2)	10.666 fg	10.000 g	14.333 ef	10.666 fg	11.416 d
	A1	21.166 b	24.000 a	21.333 b	21.666 ab	22.041 a
	A2	16.833 c	18.500 c	19.166 bc	14.000 d	17.125 b
	S1	25.333 b	29.833 a	24.166 bc	22.166 c	25.375 a
	S2	12.666 e	12.666 e	16.333 d	13.500 e	13.791 b
	L Mean	19.000 bc	21.250 a	20.250 ab	17.833 c	

LSD values 0.05 L =1.8555, A = 1.3121, S = 1.3121, A*S = 1.8616, L*A = 2.6241, L*S = 2.6241, A*S*L = 3.7111

Effect of soil sterilization

Table 5 show that sterilized soils were significantly effective and increased NS/P significantly (23.37) compared to non-sterilized soils (13.79 spikes.pot^{-1}). This might be due to minimized weed seeds and propagules that may exist in the soil which will lead to less competition between wheat plants and weeds. Results were supported by the study of Al-Chalabi and Al-Agidi (3) and Tawaha et al. (45) who mentioned that minimizing weeds increased number of crop spikes per area.

Effect of soils from different locations

Soils of L2 and L3 registered significant increase in NS/P (21.250 and 20.250 spikes.pot^{-1}) compared to L4 (17.833) spikes pot^{-1}.

Effect of interaction treatments

Interaction treatment A1S1 increased NS/P significantly to 27.916 spikes pot^{-1} (Table 5) compared to A2S2 (11.416 spikes pot^{-1}), this was supported by results of Owen and Powles (38) ,Hossain (22) and Norsworthy et al. (36). Interaction treatment A1L2 increased NS/P significantly to 24.000 spikes pot^{-1} compared to A2L4 (14.00 spikes pot^{-1}). Interaction treatment S1A2 also increased NS/P of wheat plants significantly to 29.833 spikes pot^{-1} compared to S2L1, S2L2, S2L and S2L4 (12.666, 12.666 and 13.500 spikes pot^{-1} respectively). Triple interaction treatment A1S1L2 registered the largest NS/P significantly (32.666 spikes pot^{-1}) compared to A1S2L2 (10.0 spikes pot^{-1}) which was the lowest NS/P. These results were in compatible with that obtained by Dietrich et al. (19); Richardson et al., (42), Lynch,(32), Shen et al.,(44).Results of triple interaction A1S1L2 were agreed with results of Ahmad et al.,(1) and Chaudhary et al.,(14).

Effect of cleaning wheat seeds, soil sterilization of different locations and their interactions on total spikes weight pot-1 (TSW/P).

Effect of cleaning wheat seeds

Table 6 explains the significant effect of cleaned wheat seeds on the TSW/P (36.05g) compared to not cleaned seeds (26.71 g.pot^{-1}g), the results are in harmony to what Al-Chalabi (2) and Tessema et al. (46) mentioned.

Effect of soil sterilization

Sterilized soils increased TSW/P of wheat plants significantly (Table 6) to (44.08 g) compared to non-sterilized soils (18.67g). These results were in parallel to what Javaid et al. (25) found that plant vegetative, reproductive growth and grain yield was better in heat-sterilized than in unsterilized soils.

Table 6. Effects of cleaning wheat seeds, soil sterilization of different locations, and their interactions on total spikes weight Pot^{-1}(g).

Seed cleaning (A)	Soil sterilization (S)	Soil types from different Locations (L)				Seed cleaning * Soil sterilization (A*S)
		Qlyasan (L1)	Kani Panka (L2)	Halabja (L3)	Chamchamal (L4)	
Cleaned seeds (A1)	Sterilized soil (S1)	50.558 b	61.438 a	44.468 bc	42.085 c	49.637 a
	Unsterilized soil (S2)	18.998 ef	23.027 de	27.890 d	19.936 ef	22.463 c
Not Cleaned seeds (A2)	Sterilized soil (S1)	44.933 bc	45.314 bc	40.420 c	23.471 de	38.534 b
	Unsterilized soil (S2)	12.642 f	13.656 f	18.280 ef	14.982 f	14.890 d
	A1	34.778 bc	42.232 a	36.179 b	31.011 bcd	36.050 a
	A2	28.788 d	29.485 cd	29.350 cd	19.227 e	26.712 b
	S1	47.746 b	53.376 a	42.444 b	32.778 c	44.086 a
	S2	15.820 e	18.342 de	23.085 d	17.459 e	18.676 b
	L Mean	31.783 b	35.859 a	32.764 ab	25.119 c	

LSD values 0.05 L =3.851, A =2.723, S = 2.723, A*S = 3.851, L*A = 5.446, L*S = 5.446, A*S*L = 7.702

Effect of soils of different locations

Soil from different locations had significant effect on the TSW/P (Table 6), Kani Panka soil (L2) recorded the highest spike weights significantly (35.85 g) compared to Chamchamal soil (L4) which registered 25.11 g. this may be due to the difference in soil properties or the seed bank differences of each location.

Effect of interaction treatments

Interaction treatment A1S1 caused significant increases in TSW/P (49.637g compared to A2S2 (14.890g). these results are in parallel to what mentioned by Pinto et al. (39) , Lollato (30) , Ali et al. (4), Al-Chalabi (2), and Khan et al. (27). Interaction treatment A1L2 increased TSW/P significantly to 42.232 g compared to A2L4 (19.227 g). Interaction treatment S1L2 caused a significant increase in TSW/P to 53.376 g (Table 6) compared to S2L1 and S2L4 (15.820 and 17.459 respectively). Triple interaction treatment A1S1L2 increased TSW/P significantly to 61.438 g compared to A2S2L1, A2S2L2 and A2S2L4 (12.642, 13.656 and 14.982 respectively).

Effect of cleaning wheat seeds, soil sterilization of different locations and their interactions on grain yield. g. pot^{-1}(GY/P).

Effect of cleaning wheat seeds on GY/P

Table 7 shows that wheat cleaned seed treatments caused significant increases in GY/P (25.37g compared to non-cleaned seed treatments (16.33g). It may be due to reducing weed dry weight in cleaned seed treatments (Table 3), increasing number of spikes pot-1 (Table 5), total spikes weight.pot-1(Table 6), these results are agree with the findings of Al-Chalabi and Al-Agidi (3) ,Tessema et al. (46), Khazaei et al. (28), Lollato et al. (31), Norsworthy et al. (36) and Edwards and Krenzer Jr (16).

5.2 Effect of soil sterilization

Sterilized soils found to have positive significant effect on wheat yield (Table 7). Soil sterilization caused significant increases in GY/P (28.68 g) compared to non-sterilized soils (13.01 g). This result reflects the effect of soil sterilization which leads to increased phosphorus concentration by 53% (19), phosphorus plays a vital role in the storage and transfer of energy within the cells, accelerate root development, and higher grain protein content (40, 41) . Phosphorus strengthen the wheat roots also and enhance it to deep extended in the soil to reach and absorb additional nutrient elements and water (44).

Effect of soils of different locations

Table 7 shows that Kani Panka soil recorded the highest value of GY/P significantly (24.552 g) and was superior between the four soils, especially compared to Chamchamal soil which recorded the lowest value of GY/P (15.905g). This may be due to the differences in Kanipanka soil properties which is containing more organic matter compared to other three soils (Table 1).

Table 7. Effects of cleaning wheat seeds, soil sterilization of different locations, and their interactions on grain yield pot^{-1} (g).

Seed cleaning (A)	Soil sterilization (S)	Locations (L)				Seed cleaning * Soil sterilization (A*S)
		Qlyasan (L1)	Kani Panka (L2)	Halabja (L3)	Chamchamal (L4)	
Cleaned seeds (A1)	Sterilized soil (S1)	35.423 b	43.163 a	31.954 c	27.491 d	34.508 a
	Unsterilized soil (S2)	15.449 gh	17.404 fg	18.447 f	13.66 hi	16.242 c
Not Cleaned seeds (A2)	Sterilized soil (S1)	24.853 e	27.773 d	27.619 d	11.226 j	22.868 b
	Unsterilized soil (S2)	6.562 k	9.867 j	11.519 ij	11.234 j	9.7957 d
	A1	25.436 b	30.284 a	25.200 b	20.579 c	25.375 a
	A2	15.707 e	18.820 d	19.569cd	11.230 f	16.331 b
	S1	30.138 b	35.468 a	29.786 b	19.358 c	28.688 a
	S2	11.005 f	13.636 de	14.983 d	12.451 ef	13.019 b
	L Mean	20.572 c	24.552 a	22.384 b	15.905 d	

LSD values 0.05 L =1.101, A = 0.778, S = 0.778, A*S = 1.1007, L*A = 1.556, L*S = 1.556, A*S*L = 2.201

Effect of interaction treatments:

Interaction treatment A1S1 increased grain yield pot^{-1}(GY/P) significantly to 34.508g compared to A2S2 which registered 9.7957g (Table 7). Interaction treatment A1L2 increased the GY/P significantly to 30.284g compared to A2L4 which registered the lowest value of GY/P (11.230g). Interaction treatment S1L2 also increased GY/P significantly to 35.468 compared to S2L1 which recorded 11.005g. Triple interaction A1S1L2 also increased GY/P significantly to 43.163g compared to A2S2L1 (6.562g). Results are in agreement with what mentioned by Owen and Powles,(38), Norsworthy et al., (36); Tibola et al.,(49), De Lucas Bueno and Froud Williams,(18); Kandasamy et al., (26) and Dietrich et al.,(19). Results assured that seed cleaning before sowing will enhance wheat yield and minimize weed dry weight, therefore in order to minimize using of herbicides which cause environmental pollution it is recommended to apply seed cleaning process for wheat before sowing.

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