Article

Effect of the fractionation of the nitrogen fertilization applied to the wheat crop on the quality of its seed

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Abstract

Seeds are an indispensable element in agricultural production and represent one of the means to improve crop yield and fertilization is essential for the production of high quality seeds. In the present work, the quality of the wheat seed was evaluated when the fertilizer-N is divided into different percentages. The varieties used were Gema C2004, Nana F2007 and Urbina S2007. The recommended N-P-K fertilization dose in the The Bajio region is 240-60-00. The fertilization-N divisions (FFN) were at planting, 45 days after sowing (dds) and 75 dds in the following percentages: 1) 00-00-00, 2) 100-00-00, 3) 00-100-00, 4) 50-50-00, 5) 00-50-50, 6) 70-30-00, 7) 30-70-00, 8) 00-30-70, 9) 00-70-30 and 10) 33-33-33. In the field the yield was evaluated, in the laboratory the physiological quality of the seed and in the greenhouse the vigor of the seedling in a sand bed. By fractionating the fertilizer-N at 30-70-00 and 33-33-33 the amount of m^2 seeds increased, observing higher yields in wheat production compared to the recommended fertilization-N of 50-50-00 that currently used. The best emergency percentages were presented in the subdivisions 33-33-33, 30-70-00 and 70-30-00. Regarding vigor indexes IV-I and IV-II, the treatment that showed the highest values was 30-70-00. The FFN in which the best results were observed in the variables of yield, physiological seed quality and seedling vigor was 30-70-00.

Keywords: physiological quality, nitrogen, seedling vigor.

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Introduction

The production of wheat in Mexico obtained 3.2 million tons, being the main producing states, in order of importance: Sonora, Baja California, Guanajuato, Michoacán, Chihuahua, Tlaxcala and Jalisco, which contribute with 84.9% of the national agricultural area sown, and 92.2% of the volume produced (SIAP, 2014). According to the Rector Plan for the National Product System Wheat (2011), of the registered production, only 2% is used as seed (SAGARPA and INCA, 2011). The production of qualified wheat seed that was reported by the National Service of Inspection and Certification of Seeds (SNICS) for the year 2011 reached 75 368 t. In the region known as "El Bajio", wheat cultivation is important due to the amount of surface planted, around 60 937 ha, with a production of 339 568.94 t, and an average yield of 5.61 t ha^{-1} (SIAP, 2014). Taking into account the average density of sowing is 120 kg ha^{-1} (Solis *et al*., 2007), about 7 312.44 t of seed are used, there being a deficit of certified seed.

Unlike grain production, seed production requires great care and precision in agronomic practices, where fertilization is essential for the production of high quality seeds, the quality of a seed can be expressed as the integral of four Components: physical, physiological, phytosanitary and genetic. These components are defined in the Law on Production, Certification and Trade of Seeds, published on June 15, 2007 in the Official Gazette of the Federation defined in the Law on Production, Certification and Trade of Seeds, published on June 15, 2007 in the Official Gazette of the Federation (DOF). Nitrogen (N) is the main element required for wheat production (Echeverria *et al*., 2005). Thus, deficiencies of this nutrient reduce leaf expansion, cause premature senescence and affect the photosynthetic rate, resulting in lower production of dry matter and seed (Ferraris *et al*., 2008).

An inadequate nitrogen fertilization causes a decrease of protein in the seed and can affect the germination or the vigor, for which the objective of the present work was to evaluate the effect of the fractionation of the fertilization-N (FFN) on the physiological quality of the seed of wheat, that is, measure of the ability of the seed to produce physiologically viable propagation material, which is expressed as the percentage of physiologically viable seed, with respect to the total sample of a lot.

Materials and methods

An experiment was established under field conditions in the Bajio Experimental Field (CEBAJ) of the National Institute of Agricultural and Cattle Forestry Research (INIFAP) in Celaya, Guanajuato, Mexico, located at 20° 35' 06.59'' north latitude, 100° 49' 46.84'' west longitude and altitude of 1 769 m. The physical and chemical analysis of the soil where the test was installed showed the presence of a pelic Vertisol, with a pH (1:2 water) of 7.4, organic matter content of 1.76% and clay loam texture (FAO, 1994).

The Gema C2004, Nana F2007 and Urbina S2007 wheat varieties were used, which were generated by the INIFAP for its production in The Bajio, the recommended fertilization dose in the region for NPK is 240-60-00, applying the 50 % of the fertilizer-N to the sowing and the other 50% to the 45 days after the sowing (dds) in the first relief irrigation. The fractions of the nitrogen fertilization evaluated are presented in Table 1.

Table 1. Fractionation rates of fertilization-N at 0, 45 and 75 dds.

Treatments	Planting (0 dds)	1st irrigation (45 dds)	2nd irrigation (75 dds)
	Fertilizer-N (%)		
1	0	0	0
2	100	0	0
3	0	100	0
4	50	50	0
5	0	50	50
6	70	30	0
7	30	70	0
8	0	30	70
9	0	70	30
10	33	33	33

The experimental design was of plots divided into random blocks with four repetitions. The treatments of the major plot were the varieties and the subplots were the fractionation of the nitrogen fertilization.

In the physiological maturity, the harvest was carried out. One kg of seed was collected from each of the replicates belonging to each treatment, these were homogenized and a subsample of 1 kg of seed was taken for quality analysis. For which the hectolitre weight (PH) was determined using a DICKEY-joh grain hydrometer. The weight of 1 000 seeds (PMS) was calculated by counting 1000 seeds of each of the treatments with four replications, standard germination (GE) and length of plumule (LP) were performed following the procedures published by the ISTA (1995).

The initial vigor of the seedling, using sand beds, was determined in greenhouse conditions using 50 seeds previously collected by treatment, quantifying the speed of emergence (VE) (Maguire, 1962) at 7, 8, 9 and 10 dds, and the values obtained were used to estimate the emergency percentage (%E), emergency index (IE); the index of the emergency rate (ITE) (Fakorede and Ayoola, 1980, Fakorede and Ojo, 1981; Cervantes *et al*., 2006). The aerial part dry weight (PSPA) and seedling length (LPt) were determined in a sample of 10 plants with complete competence per experimental unit at 24 dds. The PSPA and LPt variables were used to calculate the vigor index I and II (IV-I and IV-II, respectively) (Kharb *et al.*, 1994; Cervantes *et al*., 2006). In the greenhouse trial, the experimental design was a factorial design with a completely random arrangement with four repetitions.

The greenhouse experiment data were subjected to variance analysis, when the F tests were significant, the mean comparison test was performed, using the minimum significant difference (DMS) at a level of significance of 5% (SAS Institute, 2014).

Results and discussion

Yield

The analysis of variance showed that for the variety factor, there were significant differences ($p \leq 0.0001$) for all the parameters evaluated. Regarding the FFN, all the parameters were different, except for the harvest index (IC), in contrast to that reported by Barraco *et al*. (2007), who did not find significant differences in yield when fractionating N-fertilization. Variety∗FFN interactions were not significant for dry straw weight (PSP), total dry weight (PST) and IC (Table 2).

Table 2. Average squares of the analysis of individual variance of the variables for yield.

Source of variation	Gl	PSG	PSP	PST	IC
Repetitions (R)	3	6607 ns	1 775 190 ns	1 861 305 ns	0.002 ns
Varieties (V)	2	1 546 762.5**	205 106 351**	182 685 647**	0.1052**
V∗R	6	27 422.4 ns	1 879 975 ns	1 724 703 ns	0.002 ns
FFN	9	13 594 653**	62 794 751**	129 654 223**	0.006 ns
V∗FFN	18	620 747.1**	48 77 427 ns	5 999 851 ns	0.003 ns
Error	81	12 229.3 ns	28 414 858 ns	43 583 914 ns	0.002 ns
CV	-	2.03	16.88	11.01	15.16

**different from zero at a probability of 0.05; PSG= dry weight of grain; PSP= dry weight of straw; PST= total dry weight; IC= harvest index; ns= not significant.

The yields and their components obtained in the different varieties are presented in Table 3. With respect to the PSG, the Gema C2004 and Urbina S2007 varieties showed yields similar to those reported by Solis *et al*. (2007), where he mentions that the average yield in The Bajio is 5 t ha^{-1}, the variety Nana S2007 showed a higher yield in the range of 2.5-3.5 t ha^{-1}, reported by Villaseñor *et al.* (2011), this may be due to the fact that this range was determined in rainfed sowing, since this variety shows tolerance to drought. Nana F2007 showed the highest PS; however, 70.3% was straw, which is reflected in an IC of 0.31, in contrast to Gema C2004 who obtained the highest PSG and the highest IC.

Table 3. Yield of Gema C2004, Nana F2007 and Urbina S2007 wheat varieties.

Variety	Dry weight of grain	Dry weight of straw	Total dry weight	Harvest index
	(kg ha^{-1})			
Gema C2004	5 659 a*	8 172 c	13 831 c	0.41 a
Nana F2007	5 365 b	12 674 a	18 039 a	0.31 c
Urbina S2007	5 286 c	1 001 b	15 288 b	0.35 b
DMS	49.2	772.6	770.6	0.02

*= values with the same letter are statistically equal, DMS $p < 0.05$.

Regarding the FFN (Table 4), regardless of the variety, the absolute control obtained the lowest grain yields, with 3116 kg ha^{-1}, while the best was obtained by fractionating the fertilization at 30-70-00 and 33-33-33, in the order mentioned. When a single application of fertilizer-N is made, the yields are low and do not exceed 4 850 kg ha^{-1}. Also by not applying fertilization-N at the time of planting, as it is being promoted in the The Bajio region because the demand for N in the initial stages of cultivation is minimal, the yields are lower compared to the fractional application, including the sowing.

Table 4. Yield of wheat under the different fractions of N-fertilization applied at 0, 45 and 75 dds.

Fractionation fertilizer-N 0, 45 and 75 dds (%)	Dry weight of grain	Dry straw weight	Total dry weight	Harvest index
	(kg ha^{-1})			
00-00-00	3 116 i*	4 819 e	7 935 e	0.4 ns
100-00-00	4 786 h	10 721 cd	15 507 d	0.34 ns
00-100-00	4 850 h	10 005 cd	17 855 d	0.33 ns
50-50-00	6 296 c	12 435 ab	18 731 b	0.34 ns
00-50-50	5 197 g	9 866 cd	15 063 d	0.34 ns
70-30-00	5 924 d	11 219 bc	17 143 c	0.34 ns
30-70-00	6 822 a	13 454 a	20 276 a	0.34 ns
00-30-70	5 339 f	9 871 cd	15 211 d	0.35 ns
00-70-30	5 568 e	9 491 d	15 059 d	0.38 ns
33-33-33	6 469 b	10 944 c	17 413 bc	0.37 ns
DMS	89.8	1 410.6	1 407.1	0.08

*= values with the same letter are statistically equal, DMS $p< 0.05$.

The parameters PSG, PSP, PST were lower in the absolute control. The fractionation that showed the highest values of PSG was 30-70-00 with 6822 kg ha-1; however, the IC did not show significant difference. Galantini *et al*. (2007), studied the fertilizer-N application moments and concluded that when there is a greater availability of N, the development of fertile spikes is favored, they also found that the weight of the grains tends to decrease if the whole N is applied at the moment of the sowing and increases when applied in the tillering, which is related to the reduction of losses and the early translocation of assimilated to the grain. On the other hand Waddington *et al*. (1986); Siddique *et al*. (1989); Slafer and Andrade (1991), concluded that there is a directly proportional relationship between the number of m-2 grains and yield.

In the interaction variety∗FFN, significant statistical difference was observed in the components of yield, for dry weight of grain the fractionation 30-70-00 showed the highest values in each of the varieties, the FFN influenced in the yields in each one of the varieties, the same tendency of the subdivisions was also observed, the best yields were presented when the fertilizer was fractioned in 30-70-00, followed by 33-33-33. Probably due to the reduction of losses and the availability of N in the critical stages of grain formation and filling.

Seed quality

In the analysis of variance, highly significant differences were observed between the varieties and FFN for the variables PH, PMS, GE and LP; in the variety∗FFN interaction the variables PH, GE and LP also presented a highly significant difference, for the variable PMS there were no statistical differences (Table 5).

Table 5. Mean squares, degrees of freedom and level of significance of physiological quality variables evaluated in the laboratory, INIFAP-CEBAJ. Cycle A-W 2012-2013.

Source of variation	gl	Average squares[a]			
		PH (kg hL^{-1})	PMS (g)	GE (%)	LP (cm Pl^{-1})
Repetitions	3	28.67	0.56	1.16	0.01
Varieties	2	144.9 **	572.8 **	57.67 **	3.09 **
Error (a)	6	2.77	3.16	2.57	0.11
FFN	9	19.81 **	45.44 **	652.4 **	31.4 **
Varieties∗FFN	18	15.78 **	15.7 ns	21.59 **	2.63 **
Error (b)	81	3.67	5.82	2.47	0.06
CV (a)	--	2.19	4.05	1.73	4.69
CV (b)	--	2.52	5.49	1.72	3.48

*, **= statistical significance at the 0.05 and 0.01 probability level; gl= degrees of freedom; ns= not significant; CV= coefficient of variation; PH= hectoliter weight; GE= standard germination; PMS= weight of a thousand seeds; LP= length of plumule.

In the results of the comparison of means test for the varieties (Table 6), it was observed that Gema C2002 presents a value of 77.9 kg hL^{-1}, superior to the rest of the varieties. Vázquez-Mendoza (2013), found differences in the PH of commercial varieties of wheat. This parameter is important because the larger it is, the higher the proportion of starch and, consequently, the greater the extraction of flour. Therefore, the hectoliter weight is a good estimate of both the physical quality of the grain, and the milling quality. With respect to the PMS, it was observed that the Urbina S2007 variety presented a value of 47.37 g, followed by Gema C2002 with 44.38 g and Nana F2007 with 39.86 g, these results are consistent with those reported by Solis *et al*. (2009), and is due to genetic variation among varieties.

In the GE test the results were between 90-93%, they are within the standard reported by the SNICS (2013), which mentions that a minimum germination percentage for basic seed is 90%. Khabiri *et al*. (2012) evaluated 11 wheat genotypes and found a significant difference of this variable and may be due to several factors, among which are the cultivar, genetic purity, environment and maternal nutrition, among others. For the LP recorded on day seven, the varieties Nana F2007 and Urbina S2007 did not show statistical differences with 7.19 and 7.25 cm respectively, the variety Gema had the lowest value with 6.74 cm.

Table 6. Comparison of means through the DMS test for the physiological quality of seed evaluated in the laboratory, of Gema C2004, Nana F2007 and Urbina S2007 varieties, evaluated in INIFAP-CEBAJ. Cycle A-W 2012-2013.

Variety	PH (kg hL^{-1})	PMS (g)	GE (%)	LP (cm Pl^{-1})
Gema C2002	77.9 a*	44.38 b	90.27 c	6.74 b
Nana F2007	75.64 b	39.86 c	91.4 b	7.19 a
Urbina S2007	74.12 c	47.37 a	92.67 a	7.25 a
DMS	0.85	1.07	0.7	0.1

*= values with the same letter are statistically equal (DMS, $p \leq 0.05$); PH= hectoliter weight; GE= standard germination; PMS= weight of a thousand seeds; LP= length of plumule.

In the comparison of means for the FFN (Table 7), it is observed that in the PH and PMS variables the treatments 00-30-70 and 00-50-50, in which no-N fertilizer was applied to the sowing, showed the higher values, this is because the late application of N increases the protein content of the grain, this effect was reported by Echeverría and Studdert (1998), they found that the protein content in the grain responded to the interaction of applications to the planting and time dds. The treatments 00-50-50 and 00-30-70 in which no fertilizer was applied to the seeding presented the highest values in PMS 46.5 and 46.6 g, respectively. With respect to the percentage of GE, the lowest value was shown by the witness, the subdivisions that are within the SNICS standards (2013) are: 50-50-00, 00-50-50, 70-30-00, 30-70-00 and 33-33-33, it was found that there were variations according to the subdivisions of this fertilization.

Table 7. Comparison of means by the DMS test for physiological quality evaluated in the FFN laboratory, evaluated in INIFAP-CEBAJ. Cycle A-W 2012-2013.

FFN	PH (kg ha^{-1})	PMS (g)	GE (%)	LP (cm Pl^{-1})
00-00-00	75.96 bc	43.6 bcd	75.83 g	4.67 i
100-00-00	75.63 c	41.97 de	86.66 f	5.68 g
00-100-00	73.13 d	42.84 cde	88.33 e	5.29 h
50-50-00	75.51 c	44.92 ab	96.66 b	8.68 c
00-50-50	77.7 a	46.5 a	90.83 c	6.07 f
70-30-00	76.02 bc	44.82 ab	97.91 b	7.86 d
30-70-00	76.85 abc	44.53 bc	99.33 a	8.93 b
00-30-70	77.39 ab	46.68 a	89.08 de	7.1 e
00-70-30	75.38 c	41.64 de	89.83 cd	7.06 e
33-33-33	75.33 c	41.2 e	100 a	9.31 a
DMS	1.55	1.95	1.27	0.2

*= values with the same letter are statistically equal (DMS, $p \leq 0.05$); FFN= fractionation of fertilization-N; PH= hectoliter weight; GE= standard germination; PMS= Weight of a thousand seeds; LP= Plumule length.

Regarding the interaction variety∗FFN, for the variable PH Gema C2004 showed the highest value (81.17 kg ha^{-1}) when the fertilizer was divided into 00-30-70, in PMS this same fractionation reached the highest values in the variety Urbina S2007, this is due, as mentioned above, that the

low availability of N at the time of planting increases the quality characteristics of the seed; however, as shown in Table 4, the yield with this fractionation was among the lowest. In contrast, the percentage of GE in the three varieties the highest values were found in the fractions 30-70-00, 70-30-00 and 33-33-33.

Vigor of seedlings

When analyzing the characters of seedling vigor (Table 8), highly significant differences were observed in the characters VE, IE, and ITE. Similarly, in the decomposition of the mean squares for the FFN, significant differences were observed in all the characters evaluated. In the variety∗FFN interaction, the characters that showed significant differences were VE, %E, IE, ITE, LPt and IV-II. The statistical significance of the FFN indicates that the way to fractionate the N-fertilizer has both positive and negative effects on seed and seedling vigor compared to the absolute control and regional control. Salazar *et al*. (1996); Wuest and Cassman (1992), observed that in late applications of N-fertilizer in wheat, the N moves more efficiently to grain, meanwhile, Rivera-Reyes *et al*. (2009) report that with higher protein content in oat seed, there is also more phytic acid content, which is reflected in higher physiological quality.

Table 8. Mean squares, degrees of freedom and level of significance for the seedling vigor variables evaluated in the greenhouse. INIFAP-CEBAJ. Cycle O-I 2012-2013.

Source of variation	gl	Average squares[a]							
		VE (Pt d^{-1})	PE (%)	IE (d)	ITE (d)	PSPA (g)	LPt (cm)	IV-I	IV-II
Repetitions	3	0.28	4.62	0.01	0.000004	0.002	0.077	10937.9	31.16
Varieties (V)	2	64.55 **	19.73 ns	3.45 **	0.0003 **	0.01 ns	1.12 ns	2520.51 ns	81.14 **
Error (a)	6	0.04	7.28	0.006	0.000003	0.001	0.2	9041.92	16.26
FFN	9	12.57 **	638.8 **	0.08 **	0.0003 **	0.01 **	5.13 **	177 874 **	263.2 **
V∗FFN	18	5.15 **	25.65 *	0.18 **	0.00004 **	0.005 ns	1.36 *	2894 ns	53.69 *
Error (b)	81	0.45	8.37	0.01	0.000008	0.0018	0.61	16833	17.05
CV (a)	--	1.74	2.95	1.37	3.2	9.58	3.51	8.03	10.22
CV (b)	--	5.91	3.16	2.11	4.6	10.07	6.07	10.95	10.47

*, **= statistical significance at the 0.05 and 0.01 probability level; gl= degrees of freedom; ns= not significant; CV= coefficient of variation; VE= emergency speed; PE= emergency percentage; IE= emergency index; ITE= index of the emergency rate; PSPA= dry weight of the aerial part; LPt= length of seedling; IV-I= vigor index I; IV-II= vigor index II.

Regarding varieties (Table 9), it can be observed that in VE the highest value was obtained by Nana F2007 with 12.07 Pt d^{-1}, followed by Gema C2002 and Urbina S2007 with 11.49 and 10.16, respectively; for %E Gema C2002 and Nana F2007 were statistically equal with values of 90.6% and 91.4%, the highest value was 92% observed in Urbina S2007, the largest IE was 5.98 for Urbina S2007, followed by Gema C2002 and Nana F2007 with 5.64 and 5.39 days; in relation to the ITE the varieties Urbina S2007, Gema C2002 and Nana F2007 obtained 0.065, 0.062 and 0.059 and for PSPA the highest value was presented by Gema C2002 with 0.45, between Nana F2007 and Urbina S2007 there were no statistical differences. For the IV-II Gem C2002 showed the highest value with 40.8; similar results were reported by Khabiri *et al*. (2012), when evaluating

different genotypes of wheat found significant differences in the speed of germination. Regarding variables IE, E, PSPA, Martínez-Solis *et al*. (2010), observed the same trend among maize genotypes. On the other hand, the parameters LPt and IV-I did not show significant differences, these differ with that reported in the corn crop by Cervantes *et al*. (2006), who found significant differences in all parameters.

Table 9. Vigor of seedling evaluated in the greenhouse, of the varieties Gema C2004, Nana F2007 and Urbina S2007.

Variety	VE* (Pt d^{-1})	E (%)	IE (d)	ITE (d)	PSPA (g)	LPt (cm)	IV-I	IV-II
Gema C2002	11.49 b	90.6 b	5.64 b	0.062 b	0.45 a	12.96	1175	40.8 a
Nana F2007	12.7 a	91.4 ab	5.39 c	0.059 c	0.41 b	12.99	1186	38 b
Urbina S2007	10.16 c	92 a	5.98 a	0.065 a	0.42 b	12.68	119	39.4 ab
DMS	0.3	1.28	0.05	0.0013	0.01	-	-	1.83

*= values with the same letter are statistically equal (DMS, $p \leq 0.05$); VE= emergency speed; E= emergency percentage; IE= emergency index; ITE= index of the emergency rate; PSPA= dry weight of the aerial part; LPt= length of seedling; IV-I= vigor index I and IV-II= vigor index II.

In the FFN, the comparison of means indicates that there is a significant difference in all the variables evaluated (Table 10), the best PEs were presented in the divisions 33-33-33, 30-70-00 and 70-30-00, the Seedlings that showed the highest PSPA were those of treatments 00-30-70, 30-70-00, 00-100-00 and 00-50-50. The seedlings that reached greater height were those corresponding to the fractionation 00-30-70 with 13.7 cm. In relation to IV-I and IV-II, the treatment that showed the highest values was 30-70-00.

Table 10. Vigor of seedling evaluated in the greenhouse, of the fertilization-N fractions.

FFN	VE (Pt d^{-1})	PE (%)	IE (d)	ITE (d)	PSPA (g)	LPt (cm)	IV-I	IV-II
00-00-00	9.9 f *	77 e	5.6 cd	0.072 a	0.38 de	12.2 d	941e	29.7 e
100-00-00	10.3 ef	86.6 d	5.8 a	0.067 b	0.41 cd	12.5 cd	1083 d	36.1 d
00-100-00	11.4 c	88.6 cd	5.6 cd	0.063 c	0.46 ab	13.2 ab	1178 cd	40.8 bc
50-50-00	12.04 b	96.66 b	5.6 bc	0.059 d	0.42 c	13.2 ab	1361.8 a	40.9 bc
00-50-50	10.9 cd	90.3 c	5.7 ab	0.063 c	0.45 ab	13.1 ab	1190 bc	41.4 bc
70-30-00	12.5 ab	98.6 ab	5.6 cd	0.057 de	0.36 e	11.4 e	1129 cd	35.7 d
30-70-00	13 a	99.3 a	5.5 d	0.055 e	0.47 a	13.2 ab	1318.8 a	47 a
00-30-70	10.6 de	87.66 d	5.7 ab	0.065 bc	0.48 a	13.7 a	1200 bc	42.2 b
00-70-30	11.2 c	88.3 cd	5.6 cd	0.064 c	0.43 bc	13 abc	1154 dc	38.5 cd
33-33-33	12.1 b	100 a	5.7 ab	0.057 de	0.41 cd	12.8 bcd	1285 ab	41.5 bc
DMS	0.574	2.35	0.09	0.002	0.03	0.63	105.39	3.35

*values with the same letter are statistically equal (DMS, $p \leq 0.05$); VE= emergency speed; E= emergency percentage; IE= emergency index; ITE= index of the emergency rate; PSPA= dry weight of the aerial part; LPt= length of seedling; IV-I= vigor index I and IV-II= vigor index II.

In the interaction variety∗FFN, the comparison of means indicates that for the PE Gema C2004 shows the best percentages in the fractions 30-70-00, 70-30.00 and 33-33-33, like Nana F2007 and Urbina S2007, but these two fractions also obtained statistically equal results in 50-50-00.

For the PSPA values, the best fractions were 00-50-50, 30-70-00 and 00-70-30 for Gema C2004, 30-70-00 and 00-50-50 for Nana F2007, and for Urbina S2007, 00-100-00 and 00-30-70. None of the fractions coincided in the three varieties, this indicates that this variable may be linked more to the genotype than to the FFN, in the variable LPt the same behavior was observed.

Conclusions

By fractionating the fertilizer-N at 30-70-00 and 33-33-33 the amount of m^2 seeds increased, observing higher yields in wheat production compared to the recommended fertilization-N of 50-50-00 that currently used. The lowest percentage of standard germination was shown by the witness, the subdivisions that are within the SNICS standards (2013) are 50-50-00, 00-50-50, 70-30-00, 30-70-00 and 33-33-33. The best emergency percentages were presented in the subdivisions 33-33-33, 30-70-00 and 70-30-00. Regarding IV-I and IV-II, the best treatment was 30-70-00. The FFN in which the best results were observed in the variables of yield, physiological seed quality and seedling vigor was 30-70-00.

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