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Original Research Article

Estimation of wheat seeding rate based on fixed population density and test weight by displacement

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The research work was accomplished at the laboratories of the Field Crops Department, Faculty of Agriculture and Forestry, University of Duhok during the 2013-14 Season. An equation utilizing the Microsoft Excel Program was used to estimate seeding rate based on fixed number and test weight by displacement method in comparison to the common method by Hectoliter apparatus. The results show that 414/m² are sufficient for most evaluated varieties as compared to Abu Ghraib3 variety which was considered as a check variety; the final seeding rate and seeds number was adjusted according to the actual germination and purity percentages. Results also showed high correlation (r=0.885) and close relationship between both common test weight measurement method and the suggested method by displacement for small samples.

Key words: Wheat, seeding rate, population, test weight.

INTRODUCTION

Wheat population density is of great importance as it reflects subsequently crop growth and ultimately crop yield. High density encourages competition among plants in soils rich in mineral nutrients, moisture and even light, therefore it can cause crop lodging. On the other hand, low density encourages weed growth and frequently leads to reduced and impaired crop yield and quality respectively. Wheat varieties vary in their test weight either in terms of Hectoliter weight or seed index (1000 kernels weight) and seed size; even within the same varieties as it depends on the growing season, environmental conditions, water availability and temperatures during maturation and fertilizers application. Hence, absolute seeding rate values cannot be recommended for certain areas even for the same variety unless they are similar in their seed weight. Such variation in seed weight leads to variation in the number of seeds and consequently the number of plants for certain areas. Conley and John (2013) mentioned that the fall in plant stand for winter wheat was between 30 and 35 plants per square foot; however seeding rate for soft red winter wheat was between 1,300,000 and 1,600,000 viable seeds per acre depending on varietal seed size (this is equivalent to 74 to 119 pounds of seed per acre, respectively). Similarly, OCCC (2013) showed that the required number of viable seeds per square meter to achieve the desired populations for each winter and spring wheat is 400 seeds, and the following equation was formulated thus:

Seed rate (g. plot^{-1}) = (Viable seeds m^{-2} × Plot area m^2 × thousand kernels weight /1000)/actual germ% Favorable environments especially abundant moisture, optimum temperature, and available nutrients support higher seeding rates; while in delayed sowing, the rate of seeding should be increased by 15 to 20% (Ortiz, 2012). Also, Ortiz (2012) stated that wheat growers traditionally use seeding rates based on the volume or weight of the seeds; since the number of seeds in a pound can range from 10,000 to 18,000.

Therefore, seeding rates should be based on the number of seeds per acre and he suggested that the rate of 30 to 35 seeds per square foot (333.3 and 388.8 seeds per square meter, respectively) is desirable for most wheat varieties. AAF (2007) used the following equations to calculate wheat seeding rate for certain unit area:

$$\text{Seeding rate (lb/ac)} = \frac{\text{Desired plant population/ft}^2 \times \text{1,000 Kernel wt. (g)}}{\text{Seedling survival rate (in decimal form such as 0.90 / 10.4)}}$$

(Equation 1)

Therefore seeding rate for wheat (low end target) = 16 plants/ft^2 x 35 g / 0.90 / 10.4 = 60 lb/acre.

(High end target) = 30×35 / 0.90 / 10.4 = 112 lb/acre

Seeding rate (kg.ha^{-1}) = desired plant population/m^2 x 1,000 Kernel wt. (g) / seedling survival rate (in decimal form) / 100

Equation (2)

However, for pure stands, an initial bulk seeding rate can be obtained with the following formula:

Bulk seed requirement =Target pure live seed (PLS) seeding rate /percent PLS (seed certificate).

Bulk seed requirements for meadow brome in 23 cm spacing = 13 kg.ha^{-1} / 75% PLS = 17.3 kg.ha^{-1}.

Robinson and Shawn (2007) used the following equation for soybean crop:

Desired Plant Population / (germination percentage × pure seed percentage × pure live seed percentage).

Moreover, Matthews and Di (2005) used the following equation to determine seed rate for pulses:

$$\textit{Seed Rate}\ (\text{Kg.ha}^{1}) = \frac{\textit{Target plant density}\ (pl.m^{-2}) X100\ \textit{seed weight}\ (g) X\ 10}{\textit{Germination \% X Establishment \%}}$$

Robertson et al. (2004) suggested an amount of 40 to 70 pounds of pure live seed (PLS) per acre for dry land winter wheat, and this variation is due to variation in seed size, soil moisture, and seeding date. This number corresponds to approximately 12 to 22 seeds per square foot. The following equation was used for seed rate determination:

$$\textit{Actula seeding rate}\ (Ib.acre^{-1}) = \frac{\textit{Desired seeding rate}\ (Ib.acre^{-1})}{(\textit{Germination \%}/100)(\textit{Seed purity \%}/100)}$$

ABRRVI (2004) suggested a sowing rate of 120 kgha^{-1} for Abu Ghraib3 Variety, which corresponds to about 400 plants/m^2 depending on seed weight. However, Khalaf (2001) suggested the following formula for wheat seeding rate:

Seeding rate (kg. donum^{-1}) = (2500/spacing in meters × thousand seeds Wt. in gram)/(Purity% × germ.% / 100 x 10000).

Accordingly, the seeding rate for wheat seeds of 30 g thousand seeds sown at 3 cm between seeds and 15 cm between lines was: Seeding rate ((kg.d^{-1}) =

$$\frac{2500}{0.03*0.15m} * \frac{30}{95*\frac{80}{100}} * 10000 = 21.92\ kg.d^{-1}$$

where: d (donum = 2500 m^2)

In the case of 1000 seeds with 20 g weight having the same pure live seed percentage and sown at the same spacing, the seeding rate =

$$\frac{2500}{0.03m*0.15m} * \frac{20}{95*\frac{80}{100}} * 10000 = 14.61\ kg.d^{-1}$$

Shroyer et al. (1997) has reported that seeding rates vary across Kansas State like seeding dates, depends on environmental conditions. Accordingly the seeding rates are lower in Western Kansas with lower rainfall than in Central and Eastern Kansas. Moreover, Shroyer et al. (1996) reported that wheat sowing rate differ according to the seed size and seed weight.

Singh (1991) cited the following equation to estimate seeding rate:

Seeding rate (kg.ha^{-1}) = (10000 × thousand seeds weight ×100 ×100)/(1000×1000× purity% × Germination% × spacing (meters).

Seeds test weight

Test weight is the weight of seeds per unit volume and is expressed in kilograms per Hectoliter or pound per bushel. Test weight in terms of Hectoliter weight, is an important parameter as it gives an indication of seed chemical composition, seed dampness, insects infestation and seed maturation.

Conley and John (2013) stated that test weight is an important factor to consider when selecting a variety as both environment and pests may greatly affect test weight therefore, selecting a variety that has a high test weight potential in any area is critical to maximizing economic gain. Greenaway et al. (1997) reported that breeders used test weight as a general guide to combine characteristics such as kernel plumpness (fullness), density, surface features, brush development and shape.

MATERIALS AND METHODS

The research work was carried out at the Laboratories of the Field Crops Department, Faculty of Agriculture and Forestry, University of Duhok during the 2013/2014 Season. Ten bread wheat (*Triticum aestivum*) (Abu Ghraib3, Cham-6, Doma, Al-Iraq, Al-Rashid, IPA99, Bohouth-4, Tammuz-2, Adana99, and Aras) were used to estimate both sowing rate based on fixed number of seeds and test weight.

Sowing rate based on fixed number of seeds

The popular variety which is well known in the area (Abu Ghraib3*)* was selected to be the standard for sowing rate

determination based on fixed number per square meter and the following equations was applied to obtain the amount (g) and number of seeds per square meter for comparative varieties involved in the study.

Number of seeds for the standard variety (Abu Ghraib3) per square meter = (seed rate (SR1) g per donum /2500)×1000/weight of 1000 seeds (WS1) for standard variety

$$\text{Number of seeds for standard variety } (m^2) = \left[\frac{\frac{SR1}{2500}*1000}{WS1}\right]$$

Desired plant population/ft^2 × 1,000 Kernel wt. (g) = (30000/2500) ×1000/28.97= 414.22 seeds/m^2

Sowing Rate Based on Fixed Number for other varieties per square meter = Number of seeds for the standard variety × (weight of 1000 seeds/1000)

$$\text{Seeding rate for other variety } (m^2) = \left[\frac{\frac{SR1}{2500}*1000}{WS1}\right]\left[\frac{WSn}{1000}\right]$$

= (30000/2500)x1000/28.97x(34.53/1000)=14.30 $g.m^{-2}$

Seed number/m^2= 14.30x1000/34.53=414.22 $seeds.m^{-2}$

Adjusted seeding rate and number per square meter according to the actual germination and purity percentages:

Adjusted sowing rate= seeding rate for other variety (m^2)/Germination% × Purity%

The above steps can be summarized in the following equation:

$$SRF = \left[\frac{\frac{SR}{2500}*1000}{WS1}\right]\left[\frac{WSn}{1000}\right]/G\% * P\%$$

Where:

SRF: sowing rate based on fixed number ($g.m^{-2}$); SR: sowing rate for the standard variety ($g.d^{-1}$); WS1: weight of 1000 seeds for the standard variety (g); WSn: weight of 1000 seeds for the other variety (g); G: germination percentage; P: purity percentage

Therefore, the seeding rate based on fixed number for Cham6 variety of wheat which have thousand seed weight (WSn)= 34.53 g, Germination%=0.96, Purity%=0.99 in comparison to the standard variety Abu Ghraib3 (WS1) = 28.97, to be sown at SR1= 30000 g per donum is:

$$SRF = \frac{\left[\frac{\frac{30000}{2500}*1000}{28,97}\right]\left[\frac{34.53}{1000}\right]}{0.96X0.99} = 15.04\ g.m^2$$

Accordingly, seeds of ten cultivated bread wheat were collected from authentic sources and institutes, their thousand seeds weight were determined and their seeding rate on the base of the recommended rate [30 $kg.donum^{-1}$ (2500 m^2)] were estimated on the base of fixed seed number per donum for all cultivars in order to make comparison between their performance under field condition utilizing Microsoft Excel Program 2007.

Test weight (Hectoliter weight) Kg. $hectoliter^{-1}$

Test weight provides an indication of seed plumpness (fullness), soundness, healthiness and dumpiness of the wheat seed and therefore it is essential for efficient milling into white flour or seedling vigor.

The volume of certain weight of seeds of each variety was determined twice by using water displacement in a graduated cylinder according to Ahmed and Ibrar (1996). Leigh and Markwith (2011) used a graduated cylinder with 1 ml increments and 0.1 measurements precision; the volume of water displaced by a submerged seeds was equal to the volume of seeds. Tests weight for ten bread wheat was determined manually by hectoliter apparatus and compared by those estimated by displacement method which was determined by the application of the following equation:

$$\text{Test weight kg/hectoliter} = \frac{Volume\ weight\ in\ mililiter(V)/1000}{sample\ weight\ in\ gram\ (W)/1000}\ X\ 100$$

Where:

W= sample weight (g)

V= sample volume (ml)

RESULTS AND DISCUSSION

Sowing rate based on the fixed number according to the actual germination and purity percentages is shown in Table 1. The standard variety (Abu Ghraib3) with 28.97 g thousand seeds weight is usually sown at the rate of 30000 grams per donum; this corresponds to about 414 plants/m^2. The varietal comparison studies, discarding the sowing rate per unit area lead to unreasonable comparison and consequently misguided results. Therefore, the sowing rate for all varieties was calculated to be 414 plants/m^2 and then the amount of seeds (g) was adjusted according to the actual germination and purity percentages. In this concept, the suggested equation was used utilizing the Microsoft Excel Program. It is noted that the final rates of sowing for different varieties was variable and ranged from 11.57 up to 21.06 g/m^2 for Bohouth-4 and Tammuz-2 varieties, respectively; this variation was due to their germination and purity percentages. These results are concurrent with those in the literature (Conley and John, 2013; OCCC, 2013; Ortiz, 2012).

Moreover, the final number of seeds/m^2 for each variety

Table 1. Seed rate of wheat varieties based on fixed seed number per m^2 and actual germination (G) and purity (P) percentage.

Wheat variety	Sowing rate ($g.d^{-1}$)	Weight of 1000 seeds (g)	Seed rate ($g.m^{-2}$)	Fixed no. of seeds/m^{-2}	G %	P %	Adjusted seed rate ($g.m^{-2}$)
Abu Ghraib3	30000	28.97	12.00	414	0.98	0.99	12.37
Cham-6		34.53	14.30	414	0.96	0.99	15.05
Doma		40.90	16.93	414	0.92	0.99	18.70
Al-Iraq		39.58	16.39	414	0.98	0.98	17.16
Al-Rashid		27.72	11.48	414	0.96	0.97	12.31
IPA99		31.71	13.13	414	0.98	0.98	13.63
Bohouth-4		27.11	11.22	414	0.98	0.99	11.57
Tammuz-2		49.83	20.63	414	0.99	0.99	21.06
Adana99		35.50	14.70	414	0.98	0.98	15.26
Aras		38.78	16.05	414	0.98	0.98	16.78

Table 2. Adjusted seeds number per m^2 for wheat varieties depending on adjusted seed rate ($g.m^{-2}$)

Wheat variety	Weight of 1000 seeds (g)	Adjusted seed rate ($g.m^{-2}$)	Adjusted Number of Seeds. m^{-1} based on G and P %
Abu Ghraib3	28.97	12.37	427
Cham-6	34.53	15.05	436
Doma	40.90	18.70	457
Al-Iraq	39.58	17.16	434
Al-Rashid	27.72	12.31	444
IPA99	31.71	13.63	430
Bohouth-4	27.11	11.57	427
Tammuz-2	49.83	21.06	423
Adana99	35.50	15.26	430
Aras	38.78	16.78	433

Table 3. Displaced volume, estimated test weight and actual test weight of different varieties

Variety	Seed sample weight (g)	displaced volume (ml)	Estimated test weight (kg/hec) by displacement	Actual test weight (kg/hec) by apparatus
Abu Ghraib3	3	2.24	74.66	74.20
Cham-6	3	2.23	74.33	72.8
Doma	3	2.30	76.66	78.45
Al-Iraq	3	2.20	73.34	73.23
Al-Rashid	3	2.40	80.00	79.25
IPA99	3	2.30	76.67	77.50
Bohouth-4	3	2.26	75.34	78.77
Tammuz-2	3	3.20	80.00	82.22
Adana99	3	2.375	79.17	79.86
Aras	3	2.35	78.34	79.67
Correlation (r)			0.885	

was also calculated and adjusted according to their actual germination and purity percentages (Table 2). The standard variety (Abu Ghraib3) has a sowing rate of about 414 seeds/m^2 on which the sowing rate of other varieties was based and adjusted depending on their actual germination and purity percentages. Therefore, number of seeds varied between 423 seeds for Tammouz-2 to 457 for Doma variety. It is obvious that the final number (seeds/m^2

is not 414 seeds for all varieties; this was attributed to initial variation in their actual germination and purity percentages.

Table 3 shows the comparison of test weight ($kg.ha^{-1}$) determined by mechanical apparatus and displacement methods for different wheat varieties. The later method was suggested by dividing the seed volume (ml) my seed weight (g), multiplied by 100. It is obvious that the estimation of test weight by this method is simple and highly correlated (r=0.885) to the common method (apparatus). This method can be helpful for small quantities of seeds when the amount is inadequate for common methods to be used.

REFERENCES

AAF (2007). (Alberta Agriculture and Food). Using 1,000 Kernel Weight for Calculating Seeding Rates and Harvest Losses. AGRI-FACTS. Agdex 200/200-1.

ABRRVI (2004). (Annual Bulletin for Registration and Released Varieties in Iraq). National Committee for Registration and Released Agricultural Varieties. Ministry of Agriculture, Iraq. Vol. (3)

Ahmed SH, Ibra R (1996). Differential water imbibitions in wheat varieties related to germination. Pak. J. Bot.,28(1):103-108.

Conley S, John G (2013). Top 7 Recommendations for Winter Wheat Establishment in 2013. University of Wisconsin agronomy, soybean research, University of Wisconsin-Extension. www.coolbean.info.

Greenaway WT, Watson CA, Davis G (1997). Factors for converting bushel weight to hectoliter weight for six cereals grains, flax, and soybeans. Cereal Chem. 54(2):373-378.

Khalaf AS (2001). Seeding rate determination for most crops through their seed index and sowing space. J. Tikrit University for Agric. Sci. (1):4:129-133.

Leigh DS, Markwith SH (2011). Comparison of estimated and experimental sub aqueous seed transport. Ecohydrol, John Wiley & S0ns, Ltd. Online Library.

Matthews P, DI Holding (2005). Germination testing and seed rate calculation, Pulse point 20. State of New South Wales Department of Primary Industries .

OCCC (2013). Trial methods and procedures. Version 1.0 (Guide to the Operation of the Ontario Cereal Crops Committee and Genotype Testing Procedures) available on www.gocereals.ca).

Ortiz BV, (2012). Alabama Winter Wheat Production Guide. Auburn University College of Agriculture Department of Agronomy and Soils. Alabama Cooperative Extension System. ANR-0992.

Robertson LD, Stephen OG, Bradford DB (2004). Southern Idaho Dryland Winter Wheat Production Guide. University of Idaho, College of Agriculture and Life Sciences. BUL 827. P. 24-28.

Robinson AP, Shawn PC (2007). Plant Populations and Seeding Rates for Soybeans. Soybean Production Systems. AY- 217-W. Purdue extension, Purdue University.

Shroyer JP, Curtis T, Randy B, Paul DO, Dale LF, Scott S, Stewart D, Gary LK (1996). Kansas Crop Planting Guide. Kansas State University Agricultural Experiment Station and Cooperative Extension Service L-818.

Shroyer JP, Hans K, Curtis RT (1997). Wheat Production Handbook, Kansas State University, May 1997. K-State Research & Extension Manhattan, Kansas. C-529. Pp. 9-11.

Singh SS (1991). Principles and practices of agronomy. Kalyani Publishers, New Delhi.