

Article

Effects of Harvesting Method on Seed Yield and Seed Quality in *Urochloa ruziziensis* (cv. 'OKI-1' and cv. 'Br-203')

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Abstract: Two field trials were conducted in Northern Thailand from 2018 to 2020 to determine the best manual harvesting method for maximizing seed yield and seed quality of two *Urochloa ruziziensis* cultivars, cv. OKI-1 and cv. Br-203. Four manual seed harvesting methods were implicated in a randomized complete block design with four replicates. The four methods were as follows: knocking seeds from seedheads into a nylon net receptacle and collecting them once every day (T1); knocking seeds from seedheads into a nylon net receptacle and collecting them once every three days (T2); allowing ripe seeds to fall into a nylon net sheet that was stretched as a receptacle beneath the seedheads and collecting seeds once every five days (T3); and covering the tied seedheads with a nylon net bag and collecting seeds once every five days (T4). The highest pure seed yield was obtained from T3 in cv. Br-203 (333.11 kg/ha), as well as the highest trend in cv. OKI-1 (534.67 kg/ha). T3 produced 22–46% and 11–27% more pure germinated seed yields than the other methods in cv. Br-203 and cv. OKI-1, respectively. As a result, T3 was recommended for higher seed yield, convenient seed harvest, and reduced manual seed harvest time.

Keywords: *Brachiaria*; collection method; hand harvesting; manual harvesting; seed harvesting; tropical grass



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1. Introduction

Urochloa (Syn. *Brachiaria*) grass is one of the few tropical forages that provide the main source of nutrition for ruminant livestock in tropical and subtropical regions around the world. The genus *Urochloa* belongs to the Poaceae family and contains approximately 100 grass species. All *Urochloa* spp. can be grown vegetatively or from seeds. Most tropical forages, including *Urochloa* spp., are propagated using seed. Seed production is an important step in the marketing of new fodder crops. To promote the widespread adoption of existing and future *Urochloa* cultivars, abundant, low-cost, high-quality seeds are required. Furthermore, in order to be profitable, a forage grass cultivar must be capable of producing a seed crop with enough yields to be offered at a reasonable price. Increased seed production can be achieved by optimizing agronomical methods such as establishment techniques, nitrogen application, plant growth regulator use, harvesting, and seed cleaning procedures. The seed harvesting method is an important aspect of determining seed production in terms of quantity as well as quality, which includes purity and germination ability.

A new cultivar (cv.) of *Urochloa* (Synonym *Brachiaria*), 'Br-203' (*Urochloa ruziziensis* (R. Germ. and C.M. Evrard) Crins $\times$ *Urochloa brizantha* (Hochst. Ex A. Rich.) Stapf) is an apomictic hybrid produced by crossing a sexual maternal tetraploid parent (i.e., 'Miyaokikoku' (*Urochloa ruziziensis* cv. 'Miyaokikoku-ichigou') [1]) with an apomixis paternal tetraploid parent (i.e., 'Mulato' (*Urochloa ruziziensis* $\times$ *Urochloa brizantha*)). In addition, another cultivar 'OKI-1' is an open-pollinated cultivar [2] that was developed by recurrent selection through the evaluation of seed fertility and plant productivity among the base population of the tetraploid *Urochloa ruziziensis* cv. 'Miyaokikoku' [1] was obtained by the Department of Livestock Development (DLD), Thailand, after pre-selection of the desired traits in Japan. The cv. 'Br-203' exhibited high forage dry matter yield (19,200 kg/ha/year over an average of two consecutive years at five test sites in Thailand), good palatability, good regrowth and extension, moderately frequent flowering, and seed maturity rate were similar to 'Basilisk' [3]. The cv. 'OKI-1' produced a dry matter yield of 15,800 kg/ha/year in a preliminary experiment at Lampang Animal Nutrition Research and Development Center. This cultivar exhibited a significantly higher in vitro dry matter digestibility (IVDMD) at all growth stages and in all the plant parts of the plant compared with *Urochloa ruziziensis*, cv. 'Mulato II' (*Urochloa ruziziensis* $\times$ *Urochloa decumbens* (Stapf) R.D. Webster $\times$ *Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster) and *Urochloa decumbens* cv. 'Basilisk' [4].

For the widespread adoption of these cultivars, making them in demand and achieving economical production by increasing seed yield with the best agronomic management for increasing seed yield was necessary. Despite of its interest, the low seed yield of both grasses is a serious problem, the same as tropical hybrid *Urochloa* cultivars, namely Mulato, Mulato II, Cayman, and Cobra [5]. Agricultural management strategies must be developed concurrently with genetic development to establish an alternate grass cultivar for seed growers and provide for animal farmers.

Seed harvesting is the process of taking the mature seed crop from the field to obtain a maximum seed yield without damage and quality deterioration through drying, cleaning, and delivery to storage [6]. It requires crucial process in seed production and critical operation for reaching the overall crop quality. A large amount of seed loss can occur both before and during the harvest. It is related to the adequacy of crop physiological maturity and seed moisture content. Therefore, it can be affected by the improperness of harvesting time and harvesting method [7].

Choosing an appropriate harvesting method and equipment for seed harvesting should be attentively considered. It can range from a hand operation to mechanical one, depending upon the quantity of seed to be harvested, the type of product, planting, and climatic conditions [6]. Additionally, it depends on the specific attributes of the plant species, accessibility of machinery or employment, management skills of the farmer, and value of the crop, which may also be altered by the market assortment. Tropical grass seeds can be harvested by a single destructive harvest of seed attached to the standing crop, multiple non-destructive harvests from the standing crop, or ground recovery of ripe fallen seed from the standing crop [8].

In the developing countries of the tropics, manual grass seed harvesting methods are performed predominately because of the low cost and accessibility of labor, which concludes that it is suitable for a small planting area. Grass seed harvesting has been performed manually in Thailand, as well as other tropical developing countries, for over four decades, ranging from single destructive harvests to multiple non-destructive harvests. For a single destructive harvest by hand harvesting, crops are either cut with sickles and rapidly threshed or cut and then sweated before threshing. However, some research papers in Thailand have reported that multiple non-destructive manual harvests can achieve higher seed yields than single destructive harvests [9]. Multiple-non-destructive manual seed harvesting methods, which comprised tying groups of seedheads into living sheaves and knocking the seeds into broad shallow seed-net receptacles, covering and tying the seedheads with lightweight nylon net bags in order to allow the mature seed to fall into these bags by shaking and collecting them at a few day intervals, including the use of

a nylon net receptacle placed under the seedheads, were commonly used to maximize grass seed yields. Phaikaew and Pholsen [10] found that daily knocking for collecting seeds of the *Urochloa ruziziensis* into seed-net receptacles obtained 50% more seed yield than cutting and sweating. The seed harvesting method of *Panicum maximum* TD.58 by covering the tied seedheads with a nylon net bag and collecting seeds every 3–5 days showed a higher seed yield and a thousand seed weight than the method of shaking the tied seedheads and collecting seeds every 3–5 days (792.5 kg/ha vs. 571.9 kg/ha and 1.398 g vs. 1.327 g, respectively) [11]. The highest pure seed yield (PSY) of *Panicum maximum* cv. ‘Mombaza’ was obtained by covering the seedheads with a nylon net bag and using a nylon net receptacle placed under the seedheads when compared with the shaking of seedheads into a large net receptacle every 3 days or daily [12]. In addition, the method of tying lightweight nylon net bags over seedheads produced substantially higher seed yields than knocking seedheads and ground sweeping for cv. ‘Mulato’ and cv. ‘Mulato II’ [9]. Even though Kamphayae et al. [13] found no significant difference in seed yield between seed harvesting methods, the highest seed germination percentage (91%) and TSW (1.352 g) of *Panicum maximum* cv. ‘Umaku’ was obtained by covering seedheads with a nylon net bag and collecting seeds one time, while the lowest was gained by the method of daily shaking seedheads.

Although manual seed harvesting methods are still widely used in the countries to produce high-quality commercial seeds through intensive collection, they face a number of challenges, including labor shortages and higher wages during the peak harvesting season, which coincides with rice harvesting, and adverse weather conditions that are responsible for numerous seed losses. Therefore, it is important to find effective manual harvesting methods to maximize seed yield and seed quality and reduce the problems occurring at harvest time.

The main objective of this research was to determine the most effective multiple non-destructive hand harvesting method for maximizing seed production of two new *Urochloa* cultivars, OKI-1 and Br-203, in Northern Thailand, based on the methods successfully used for other tropical grasses in Thailand.

2. Materials and Methods

2.1. Location, Soil Characteristics, and Meteorological Data of the Experimental Sites

Two field trials were conducted at the Lampang Animal Nutrition Research and Development Center (Lampang ANRDC), Lampang, Northern Thailand (18.3° N, 99° E; 320 m asl) from May 2018 to February 2020. The soil is acidic and classified as the Renu soil series, which is characterized by fine sandy loam to sandy clay loam soil, poor drainage, and low fertility [14,15]. Initial soil samples were taken from a soil depth of 10 cm in May 2018, and post-harvest soil samples were taken in December 2019. The chemical properties of initial soil samples from field trial sites are shown in Table 1.

Table 1. Chemical properties of preliminary soils collected from both experimental sites.

Trial	pH	OM (%)	Total N (%)	Extractable (mg/kg)										EC (dS/m)
				P	K	Ca	Mg	Na	S	Mn	Fe	Cu	Zn	
1	5.22	0.71	0.04	2.72	51.71	74.44	11.45	3.38	2.45	19.12	54.48	0.19	0.02	0.41
2	5.33	0.49	0.02	0.64	81.13	278.42	43.53	2.44	2.75	10.78	46.91	0.15	0.06	0.30

Abbreviations: OM, organic matter; EC, electric conductivity.

The meteorological, climatological, and geophysical characteristics of air temperature, rainfall, number of rainy days per annum, relative humidity, sunshine duration/day, and day length in 2018 and 2019 at the Lampang ANRDC site are shown in Figure 1.

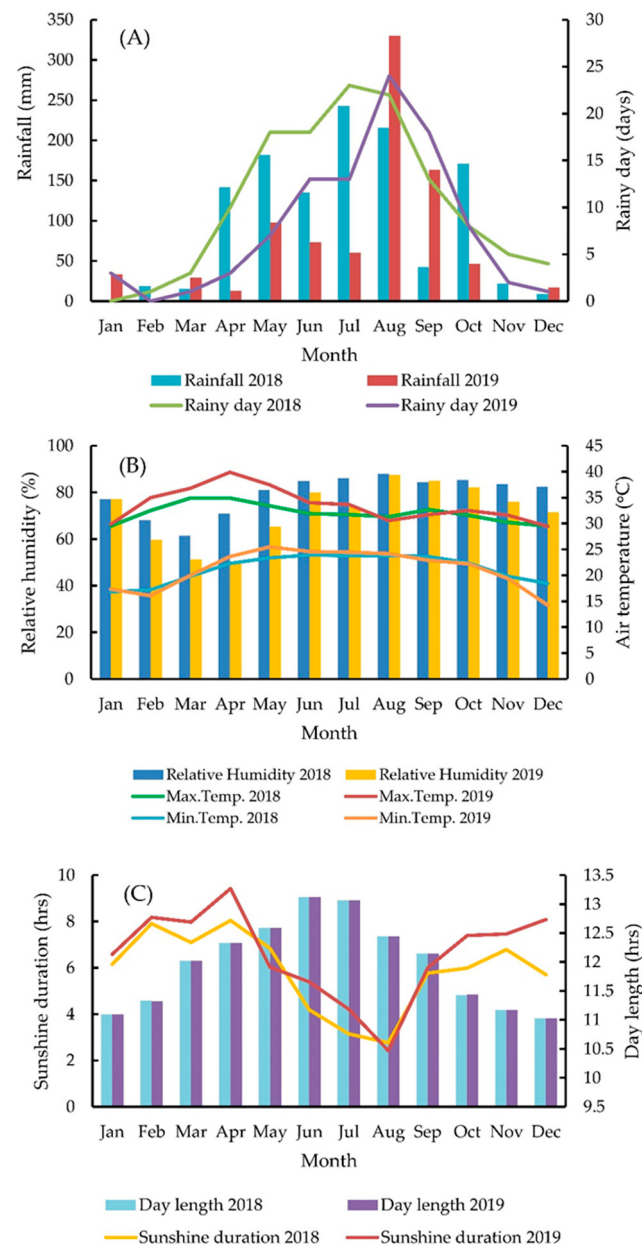


Figure 1. Meteorological data at the Lampang Animal Nutrition Research and Development Center in 2018 and 2019: (A) the average monthly rainfall and the number of rainy days in a month; (B) the monthly average relative humidity, the monthly average minimum, and the maximum temperature; (C) the monthly average day length and average daily sunshine duration.

The annual rainfall in 2019 (864.5 mm with 93 rainy days) was less than in 2018 (1194.8 mm with 125 rainy days). The maximum rainfall in 2018 and 2019 was in July (242.8 mm) and August (330.1 mm), respectively, while there was no rain in January 2018 and February 2019. The mean temperature, sunshine duration, and relative humidity of 2018 were 26.6 °C, 5.9 h/day, and 79.5%, and in 2019, they were 27.4 °C, 6.6 h/day, and 71.6%, respectively. The day length was the same in both years, averaging 12 h/day.

2.2. Trial 1—Effect of Harvesting Methods on Seed Yield and Seed Quality in OKI-1 Cultivar

2.2.1. Plant Cultivation

Thirty-day-old seedlings of OKI-1 were transplanted on 23 June 2018 at a spacing of 1 × 1 m, using a plot size of 4 × 5 m. A basal fertilizer dressing (312.5 kg/ha, NPK 15%: 15%: 15%) was applied with an additional application of 28 kg N/ha as urea at planting

time. One week after transplantation, dead seedlings were replaced with fresh seedlings (grown at the same time as the dead seedlings) to obtain a uniform stand. Two months later, each tussock was tied together into manageable bunches with plastic ropes and loosely tied to a bamboo stake using a plastic-coated wire to avoid expanding the growth cover over the ground. The bamboo stake was fixed on the ground near each tussock. Weeding was performed manually during the experiment. In the first year, the stand was established, and no defoliation or cutting was performed. After the first seed harvest, all plots were cut to 10 cm above ground level to remove all the forage on 28 December 2018. Within one day after cutting, the plant residues were manually removed. Then, topdressing urea was applied at 28 kg N/ha immediately. In the following year (2019), the grass was closed-cut on July 20 (the beginning of the rainy season). On 11 September, each tussock was tied together into manageable bunches with plastic ropes and loosely tied to the bamboo stakes with plastic-coated wire, the same as in 2018.

2.2.2. Experimental Design and Treatments

A trial was performed using a randomized complete block design (RCBD) with four manual harvesting methods and four replicates. The treatments were as follows:

T1—knocking the seeds from seedheads into a broad, shallow nylon net receptacle and collecting them once every day (Daily knocking);

T2—knocking the seeds from seedheads into a broad, shallow nylon net receptacle and collecting them every three days (3-day knocking);

T3—allowing ripe seeds to fall into a nylon net sheet stretched as a receptacle positioned beneath the seedheads and collecting them every five days (Under);

T4—covering the tied seedheads with a light-weight nylon net bag, allowing the ripe seeds to fall into the nylon-net bag, and collecting them every five days (Cover).

T1 and T2 seed harvesting methods are shown in Figure 2. T3 is depicted in Figure 3, with three fine-mesh nylon net sheets per plot. The two nylon net sheets (A) were 1.2 m wide and 5 m long. The other was a nylon net sheet (B) with a width of 1.2 m and a length of 3 m. Following the red arrow directions, the bunches of grass plants, particularly the inflorescences, were bent towards the nylon net sheets. Figure 3 also shows the experimental plots during seed harvesting. When harvesting seeds, ripe seeds were threshed off the inflorescence by lightly tapping them onto the nylon net sheet. The fallen seeds were scooped off the nylon net sheets and placed in two fine-mesh nylon bags prepared for seed collection in each plot. One bag was used to gather seeds from two 'A' nylon net sheets (border rows of grass plants), and the second bag was used for collecting seeds from six plants inside the plot from a 'B' nylon net sheet. To prevent edge effects and bias produced by abiotic environmental elements that affected each grass plant (i.e., sunshine, wind, humidity), only seed gathered from the 'B' nylon net sheet in each plot was used to assess seed yield. The seed harvesting method of T4 is shown in Figure 4.



Figure 2. T1 and T2 seed harvesting methods.



Figure 3. T3 seed harvesting method.



Figure 4. T4 seed harvesting method.

2.2.3. Data Collection and Seed Harvesting

All seedheads within each plot, except for the border row, were harvested over the period of seed maturity (late November–early December). The flowering and seed harvesting dates are shown in Table 2. The total number of tillers per plant was counted on three randomly selected plants in each plot at the time of harvest. The number of inflorescences per tiller (IN/T) was counted from 15 randomly selected tillers from the three selected plants. The number of racemes per inflorescence (RN/I) was counted from 15 randomly selected inflorescences of the three selected plants. The number of spikelets per raceme (SN/R) was averaged from the upper-, mid-, and lower-racemes of each inflorescence, which was randomly selected from the 15 inflorescences of the same three selected plants. SN/R were counted only in 2019. Tiller fertility was expressed as the percentage of inflorescences over the total number of tillers. All the inflorescences in each plot were tied together into manageable bunches when the seed was almost ripe. Each seed harvesting method was carried out according to the experimental plan. For T1 and T2, ripe seeds were threshed off the inflorescence by lightly knocking them into the nylon-net receptacle when collecting seeds. For T3, the ripe seeds were shed into a nylon net sheet, which was stretched as a receptacle and placed under the seedheads when the first flower emerged. The nylon net sheets were tied together with bamboo stakes at 1 m above ground level. The plots were harvested individually.

Table 2. Date of start flowering and harvesting period in both trials.

Event	Year	
	2018	2019
Start of flowering	16 October	13 October
Period of harvesting	20 November–12 December	3 December–25 December
Post-harvest cut of herbage	16 December	30 December

2.2.4. Seed Processing and Calculation of Secondary Attributes

After harvest, the seeds were air-dried for several days in the shade before being sun-dried for a few days and then cleaned using a hand screen. The inert fraction and

empty or light seeds were sorted out from albuminous seeds (filled seeds) by a seed blower. Then, these seed samples were kept in paper bags for seed testing. Seed yield (SY) was measured for each plot. Seed moisture content (SMC), thousand seed weight (TSW), purity percentage (PP), and germination percentage (GP) were determined following the test methods of the International Seed Testing Association for *Urochloa ruziziensis* [16]. The TSW was determined from pure-seed spikelet weight. Purity analysis was performed by separating the pure seed fraction from inert matter and other seeds in each sample and then separately weighing the pure seed fraction. The PP was calculated as the (weight of pure seed) $\times$ 100/(total weight of sample). The germination test was performed 90 days after seed harvesting in each experimental year. The SY was corrected to 11% SMC. The percentage of fertile tillers (FTP), tiller number/m² (TN), inflorescence number/m² (IN), number of fertile tillers per plant, and filled seed percentage (FSP) were calculated. The FTP was calculated as $FTN \times 100 / TN$, the pure seed yield (PSY) was calculated as $SY \times PP / 100$, and the pure germinated seed yield (PGSY) was calculated as $PSY \times GP / 100$.

2.2.5. Statistical Analysis

The data were analyzed, and the estimated variance components in the RCBD and the treatment means were tested by the least significant difference using R software version 4.1.0. [17], and significant differences between means were declared at $p < 0.05$.

2.3. Trial 2—Effect of Harvesting Methods on Seed Yield and Seed Quality in Br-203 Cultivar

The experimental site of this trial was far from the experimental site of trial 1, approximately 30 m. The plant cultivation, experimental design and treatments, data collection and seed harvesting, seed processing and calculation of secondary attributes, and other management practices, including statistical analysis for Br-203, are the same as in trial 1.

3. Results

3.1. Trial 1—Effect of Harvesting Methods on Seed Yield and Seed Quality in OKI-1 Cultivar

As shown in Tables 3 and 4, the different methods of seed harvesting did not have a significant effect on seed yield ($p < 0.05$) in each year and the two-year average. The seed yield in 2018 was almost twice as many as in 2019. The highest TSY, PSY, and PGSY tended to be obtained from T3 in 2018 and T2 in 2019. However, the tendency for the highest seed yield of the two-year average was obtained from T3. Several seed yield components were variable over the two years of the experiment. In 2018, and on a two-year average, a large number of IN and IN/T were achieved from T1. The lower TN, IN and IN/T were obtained in the second year of the experiment when compared with the establishment year, in contrast to FTN, FTP and RN/I. Most seed quality attributes, except PP, were not influenced by the harvesting method. The lowest PP was found in T1. The PP and TSW were lower in 2019 than in 2018. In contrast, a higher GP was observed in 2019. The FSP and TSW of T1 tended to be the lowest in both two years of the experiment. T1 resulted in the significantly lowest PP in both 2019 and the two-year average, and it also tended to be the lowest in 2018.

Table 3. Effect of harvesting methods on seed yield and its components in OKI-1 cultivar.

Year	Harvesting Method	TSY (kg/ha)	TN (No./m ²)	FTN (No./m ²)	IN (No./m ²)	FTP (%)	IN/T (No.)	RN/I (No.)	SN/R (No.)
2018	T1 'Daily knocking'	579.96	84.17	55.50	238.18 ^a	65.72	4.32 ^a	2.86	-
	T2 '3-day knocking'	660.42	88.58	58.33	182.26 ^{ab}	65.40	3.12 ^b	3.26	-
	T3 'Under'	764.83	72.83	45.83	118.38 ^b	62.32	2.57 ^b	3.34	-
	T4 'Cover'	669.60	75.75	50.17	144.30 ^b	66.14	2.90 ^b	3.35	-
2019	T1 'Daily knocking'	253.26	80.25	78.00	115.83	97.31	1.48	4.17	34.40
	T2 '3-day knocking'	362.18	78.50	75.42	119.98	96.08	1.60	4.19	36.62
	T3 'Under'	307.68	69.83	68.50	105.73	97.83	1.48	4.34	33.66
	T4 'Cover'	311.23	74.42	73.08	101.23	98.15	1.35	4.24	32.54
2-y avg	T1 'Daily knocking'	416.61	82.21	66.75	177.00 ^a	81.51	2.90 ^a	3.52	-
	T2 '3-day knocking'	511.30	83.54	66.88	151.12 ^{ab}	80.74	2.36 ^b	3.72	-
	T3 'Under'	536.25	71.33	57.17	112.06 ^b	80.07	2.02 ^b	3.84	-
	T4 'Cover'	490.42	75.08	61.62	122.77 ^b	82.14	2.12 ^b	3.80	-

Abbreviations: TSY, total seed yield; TN, tiller number per square meter; FTN, fertile tiller number per square meter; IN, inflorescence number per square meter; FTP, fertile tiller percentage; IN/T, inflorescence number per tiller; RN/I, raceme number per inflorescence; SN/R, spikelet number per raceme. Note: ^{a, b} Mean values with different superscript letters within the same year on the same column differ significantly ($p < 0.05$).

Table 4. Effect of harvesting methods on seed quality in OKI-1 cultivar.

Year	Harvesting Method	FSP (%)	TSW (g)	PP (%)	PSY (kg/ha)	GP (%)	PGSY (kg/ha)
2018	T1 'Daily knocking'	32.03	9.12	99.72	578.41	81.75	473.06
	T2 '3-day knocking'	40.12	9.60	99.82	659.23	77.25	528.97
	T3 'Under'	40.65	9.53	99.78	763.14	88.00	683.61
	T4 'Cover'	32.19	9.42	99.88	668.74	77.75	519.67
2019	T1 'Daily knocking'	32.67	8.21	97.78 ^b	246.64	96.25	236.65
	T2 '3-day knocking'	33.28	8.76	98.62 ^{ab}	357.49	95.00	339.95
	T3 'Under'	38.14	8.91	99.50 ^a	306.20	95.75	293.39
	T4 'Cover'	35.67	8.85	99.78 ^a	310.53	92.50	287.25
2-y avg	T1 'Daily knocking'	32.35	8.66	98.75 ^b	412.53	89.00	354.85
	T2 '3-day knocking'	38.76	9.18	99.22 ^{ab}	508.36	86.12	434.46
	T3 'Under'	39.40	9.22	99.64 ^a	534.67	91.88	488.50
	T4 'Cover'	33.35	9.13	99.82 ^a	489.64	85.12	403.46

Abbreviations: FSP, filled seed percentage; TSW, thousand seed weight; PP, purity percentage; PSY, pure seed yield; GP, germination percentage; PGSY, pure germinated seed yield. Note: ^{a, b} Mean values with different superscript letters within the same year on the same column differ significantly ($p < 0.05$).

3.2. Trial 2—Effect of Harvesting Methods on Seed Yield and Seed Quality in Br-203 Cultivar

As shown in Tables 5 and 6, a significant effect of the seed harvesting methods on seed quality was not detected ($p < 0.05$). Although a significant difference between treatments for TSY in the two-year average and PSY in both 2019 and the two-year average was found, there was no significant difference in PGSY in each year of the experiment and in the two-year average. A significant effect of the seed harvesting method on TN and FTN was found ($p < 0.05$) in 2018, and a significant difference in IN and IN/T was detected ($p < 0.05$) in 2019. In the first year of the experiment, T1 had significantly more TN than T2 and T3 and also markedly more FTN than T3. However, a significant difference between treatments in all seed yield components was not found in the two-year average. In both years, the harvesting methods had no effect on all seed quality attributes (i.e., FSP, TSW, PP, and GP).

Table 5. Effect of harvesting methods on seed yield and its components in Br-203 cultivar.

Year	Harvesting Method	TSY (kg/ha)	TN (No./m ²)	FTN (No./m ²)	IN (No./m ²)	FTP (%)	IN/T (No.)	RN/I (No.)	SN/R (No.)
2018	T1 'Daily knocking'	277.10	68.42 ^a	52.00 ^a	218.12	76.27	4.17	3.27	-
	T2 '3-day knocking'	257.28	54.00 ^b	40.25 ^{ab}	178.64	73.48	4.38	3.27	-
	T3 'Under'	417.89	53.08 ^b	38.92 ^b	163.34	72.77	4.25	3.17	-
	T4 'Cover'	379.15	62.75 ^{ab}	45.83 ^{ab}	172.69	73.06	3.75	2.79	-
2019	T1 'Daily knocking'	136.80	79.00	71.08	85.50 ^b	88.53	1.22 ^c	4.88	34.40
	T2 '3-day knocking'	160.67	94.92	82.42	143.88 ^{ab}	86.80	1.70 ^b	4.08	36.62
	T3 'Under'	268.37	83.67	77.25	155.45 ^{ab}	92.40	2.12 ^a	4.33	33.66
	T4 'Cover'	197.61	101.83	90.92	164.27 ^a	89.67	1.80 ^{ab}	4.05	32.54
2-y avg	T1 'Daily knocking'	206.94 ^b	73.71	61.54	151.81	83.08	2.69	4.07	-
	T2 '3-day knocking'	208.97 ^b	74.46	61.33	161.26	81.96	3.04	3.63	-
	T3 'Under'	343.13 ^a	68.38	58.08	159.40	84.82	3.18	3.80	-
	T4 'Cover'	288.38 ^{ab}	82.29	68.38	168.48	83.39	2.78	3.42	-

Abbreviations: TSY, total seed yield; TN, tiller number per square meter; FTN, fertile tiller number per square meter; IN, inflorescence number per square meter; FTP, fertile tiller percentage; IN/T, inflorescence number per tiller; RN/I, raceme number per inflorescence; SN/R, spikelet number per raceme. Note: ^{a, b} Mean values with different superscript letters within the same year on the same column differ significantly ($p < 0.05$).

Table 6. Effect of harvesting methods on seed quality in Br-203 cultivar.

Year	Harvesting Method	FSP (%)	TSW (g)	PP (%)	PSY (kg/ha)	GP (%)	PGSY (kg/ha)
2018	T1 'Daily knocking'	28.93	6.94	98.52	273.46	34.50	90.17
	T2 '3-day knocking'	24.28	7.28	98.12	252.93	35.00	87.11
	T3 'Under'	17.53	6.89	97.52	407.70	41.12	180.71
	T4 'Cover'	14.62	6.96	98.10	373.79	39.19	140.27
2019	T1 'Daily knocking'	26.72	6.51	97.15	133.05 ^b	94.25	125.44
	T2 '3-day knocking'	12.26	6.49	97.42	156.52 ^{ab}	95.25	148.98
	T3 'Under'	15.33	7.45	96.70	258.52 ^a	84.25	219.55
	T4 'Cover'	10.57	6.69	96.32	190.61 ^{ab}	89.75	170.82
2-y avg	T1 'Daily knocking'	27.83	6.72	97.84	203.26 ^b	64.38	107.80
	T2 '3-day knocking'	18.27	6.88	97.78	204.72 ^b	65.12	118.04
	T3 'Under'	16.43	7.17	97.11	333.11 ^a	62.69	200.13
	T4 'Cover'	12.59	6.83	97.21	282.20 ^{ab}	64.47	155.54

Abbreviations: FSP, filled seed percentage; TSW, thousand seed weight; PP, purity percentage; PSY, pure seed yield; GP, germination percentage; PGSY, pure germinated seed yield. Note: ^{a, b} Mean values with different superscript letters within the same year on the same column differ significantly ($p < 0.05$).

4. Discussion

Although the soil at both study sites was acidic, with low organic matter content (less than 1%) and deficits in essential nutrients, OKI-1 and Br-203 demonstrated the potential for edaphic adaptation in growth and productivity (Table 1). Most commercial *Urochloa* species are adaptable to a wide variety of soil types, from low-fertility acid soils to high-fertility neutral soils, as shown in the conventional report [18]. The weather conditions, especially rainfall, greatly influence seed set and pure live seed yield [19]. *Urochloa* species are generally grown in higher rainfall areas (more than 2000 mm/year), but they can be used with a minimum of about 1000 mm of annual rainfall in Australia [20] and even used in areas with an annual rainfall as low as 700 mm with a dry season of 5–6 months in some *Urochloa* hybrids [21]. During the study period (7 December 2018 to 24 December 2019) in Thailand, the annual rainfall was 855.9 mm with 96 rainy days, conforming to the range as mentioned above. The grasses received 112.47 mm/month of rain in the growth period (June to November 2019), which was sufficient for growth as Bouathong et al. [22] stated that the monthly rainfall requisite of *Urochloa* grass throughout its growth period is 83–125 mm. The maximum rainfall in August 2019 was 330.1 mm with 24 rainy days. During that time, grasses had been regrowing after closed cutting and applying N; thus, it was a proper time for their growing cycle.

In northern Thailand, the dry season spans from November through May of the following year. However, there was a slight rainfall at the beginning of flowering and at the harvest time of this study. Due to less rainfall during the start of flowering and the end of

seed harvesting (total rainfall was 122.8 mm and 13.5 mm in 2018 and 2019, respectively), the rainfall could not be enough to cause seed shattering losses or reduce seed quality, and the lower rainfall also could not interrupt the seed as it reached physiological maturity and ripeness.

The report by Nadew [23] concluded that rainfall and temperature are some of the key climatic conditions that strongly affect the state of the physiological processes in seeds and eventually affect the yield and quality of seeds. The important role of temperature is the similar to rainfall. According to Bouathong et al. [22], the optimum temperature and relative humidity (RH) for *Urochloa* species were 25–35 °C and 60–70%, respectively. The average air temperature and RH throughout the year (2019) were 27.4 °C and 71.6%, respectively. They were in a suitable range, though the RH was somewhat higher.

Apart from the factors mentioned above, the sufficiency of solar radiation and favorable photoperiods at each stage of the growth cycle, including dry weather during maturation and harvest, also affected the production of forage seed crops. The average day length all year round throughout the experimental period was approximately 12 h/day (11 h/day in December to 13 h/day in June), and sunshine duration averaged 6.6 h/day, with the shortest in August (approximately 3 h/day) and the longest in April (approximately 9 h/day). These weather factors were probably enough and suitable for the growth and blooming of plants, complying with the reports by Wongsuwan [24] that critical day length trigger reproductive development of *Urochloa ruziziensis* in Thailand, approximately 12½ hours, and he found that the greatest of seed yield was obtained from the shorter day length (11 h) than the other longer day lengths (14, 13, and 12 h).

Ison and Hopkinson [25], referenced by Hopkinson et al. [26] stated that some *Urochloa* spp. plants, such as *Urochloa mutica*, are obligate short-day plants, and *Urochloa ruziziensis* is a quantitative short-day plant, both flowering with enough vigor for useful seed production only after the autumnal equinox in the high tropics and subtropics. *Urochloa decumbens*, *Urochloa humidicola*, and *Urochloa brizantha* were inferred to be quantitative long-day plants, flowered everywhere on the longer days and more vigorously at high tropical latitudes than at low tropical latitudes. According to the results, OKI-1 and Br-203 exhibited the abilities to match the climatic conditions, day length, and soils in northern Thailand.

The severe weather is a major problem in seed production. Frequent rainfall, combined with high temperatures or drought during flowering and seed development, had a great influence on seed production. In particular, too much rainfall during pollination increases lodging and reduces pollination, which ultimately reduced seed yield. Moreover, high rainfall can wash away some pollen and causes pollen degradation [27,28]. As a result, there was no concern with excessive rainfall in this trial.

Making a choice of seed harvesting method for two new *Urochloa* cultivars is very important for achieving good seed yield with high quality. To meet a reasonable price, an effective seed harvesting method must be chosen to maximize seed production. To compete in price with other commercial *Urochloa* cultivars in South America, Hare et al. [9] claimed that seed yield must reach at least 500 kg/ha. In Thailand, achieving high seed yield with good quality of *Urochloa* hybrids has been a challenge. Some *Urochloa* hybrids tested in Thailand failed to provide satisfactory seed yield. In seed production trials conducted by DLD in Northern Thailand, Mulato II produced significantly more seed (494 kg/ha) than Mulato (163 kg/ha) [29], but Mulato produced significantly more seed (331 kg/ha) than Mulato II (119 kg/ha) in Northeast Thailand [30]. However, these yields were lower than the seed yield of *Urochloa ruziziensis* (3–4 times) in the same experiments. In our trials, only OKI-1 produced PSY more than 500 kg/ha by T3 and T2 methods. The 'Under' method (T3) had a tendency to produce higher seed yields than the 'Knocking seedheads' (T1 and T2) and the 'Cover' method (T4) for both OKI-1 and Br-203.

Although the method of seed harvesting had no significant effect on the seed yield of OKI-1, allowing the ripe seeds to shed into a nylon net sheet which was stretched as a receptacle positioned beneath the seedheads and collecting seeds every five days (T3) brought a tendency to increase more seed yield than the other methods. The 'Under'

method increased 12–16% more seed yield than the others. This was in line with a previous study on the seed harvesting method of *Paspalum atratum* in Thailand; the highest PSY was obtained from using a nylon net receptacle placed under the seedheads (the 'Under' method) and using a nylon net bag covered seedheads (the 'Cover' method). Though there was no significant difference between the two methods, the 'Under' method produced almost 12.5% more PSY than the 'Cover' method [31]. This contrasted with the study on *Paspalum atratum*, which was conducted by Kowithayakorn and Phaikaew [32] and Hare et al. [33]; the highest seed yield was obtained from knocking ripe seed daily into bags. Due to the mature seeds spontaneously shedding into a nylon-net sheet without disturbing management during seed harvesting, the 'Under' method (T3) gave the highest seed yield compared with the other methods. Furthermore, the 'Under' method avoids immature seeds and allows them to continue ripening on the plant. In the second year of both trials, seed yield was found to be lower, about half of the first year, though N fertilizer was applied. As proven by Gelderman et al. [34], seed yield can decline after the year of establishment, with or without N application.

In the case of Br-203, the 'Knocking' method (T1 and T2) brought significantly lower TSY and PSY compared with the 'Under' method (T3), though the significant difference ($p < 0.05$) between the 'Cover' method (T4) was not detected. The 'Under' method (T3) increases 22–46% more seed yield than the other methods. One reason for the lower seed yield in the 'Knocking' method of our study may be that the immature seeds were shed from the seedheads apart from the fully mature seeds during harvest. The significant differences ($p < 0.05$) in TN and FTN were found in the establishment year (2018) because the closing cut was not complete, resulting in the variation in the tiller number. In spite of the fact that the overall TN, FTN, RN/I, and FTP in 2018 were lower than in 2019, during which more TSY and PSY were obtained. It could be caused by the significant decrease in IN and IN/T, as well as in FSP, TSW, and PP. The TSW was slightly lower in 2019 than in 2018, except in the 'Under' method. The tendency of the highest PGSY was obtained from the 'Under' method as same as the case of OKI-1. With this method, only ripe and completely mature seed was harvested without damage. However, the 'Under' and 'Cover' methods appear to provide higher seed yield than the 'Knocking' method. Similar results were obtained with *Paspalum atratum* [31].

The PSY of both cultivars in 2019 was reduced by approximately half in comparison with 2018. Apart from the reduction in nutrients in the soil by plant assimilation throughout the two-year experiment, the poor seed yield could be related to water stress during the reproductive stage. This could be confirmed by Wongsuwan [35], who reported that the seed yield of *Urochloa ruziziensis* was affected by various levels of water stress in terms of physiological and morphological alterations, especially when the stress was maintained throughout reproductive development. Sehgal et al. [36] validated this finding, stating that drought and heat stress have a significant impact on seed yield by reducing seed size and quantity, consequently affecting seed weight and quality. In addition, seed filling is regulated by several metabolic processes occurring in the leaves, especially the production and translocation of photoassimilates, importing precursors for the biosynthesis of seed reserves, minerals, and other functional elements. These processes are extremely sensitive to drought and heat, due to the involvement of an array of various enzymes and transporters, located in the leaves and seeds. The browning and dieback of leaves and stems, as well as the premature death of spikelets, were discovered in some clumps of grass plants. Furthermore, considerable high values were shown in GP with 2019 compared with 2018, particularly in Br-203. The lower GP in 2018 might have been caused by the higher relative humidity during flowering to harvesting time, continuing rain until harvested, and also shorter sunshine duration during the drying process, which resulted in mold growing in some seeds during germination testing.

5. Conclusions

The results of this study recommend that allowing ripe seeds to fall into a nylon net sheet stretched as a receptacle positioned beneath the seedheads and collecting them every five days (T3) is suitable for manual seed harvesting in the two new *Urochloa* cultivars. Aside from obtaining a higher seed yield, the T3 method is also easier to handle seed collection and important for decreasing the time spent and minimizing labor costs. Even though this method is at risk of being destroyed by pests (i.e., insects, birds, and rodents), frequent seed harvest is likely to mitigate the problem. Additionally, this method could avoid seedhead damage caused by covering with a nylon net bag or directly knocking the seedheads.

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References

1. Ishigaki, G.; Gondo, T.; Suenaga, K.; Akashi, R. Induction of tetraploid ruzigrass (*Brachiaria ruziziensis*) plants by colchicine treatment of in vitro multiple-shoot clumps and seedlings. *Grassl. Sci.* **2009**, *55*, 164–170. [[CrossRef](#)]
2. Kouki, K.; Ishigaki, G.; Akashi, R.; Shimabukuro, H. *The Newly-Bred Cultivar Production in Brachiaria Grass. (1) Production of the High Seed Yield Strains Using Sexual Tetraploid Ruzigrass ‘Miyaokikoku-Ichigou’*, Annual Report; Okinawa Prefectural Livestock and Grassland Research Center: Uruma, Japan, 2014; Volume 52, pp. 73–75. (In Japanese)
3. Nakmanee, G.; Ebina, M.; Shimoda, K.; Thaikua, S.; Srisomporn, W.; Patipan, C.; Suenaga, K.; Ando, S.; Kouki, K.; Ishigaki, G.; et al. A new candidate cultivar of *Brachiaria* grass ‘Br-203’ developed with apomixis marker assisted selection, through a collaborative breeding activity of Thailand and Japan. In Proceedings of the 23rd International grassland congress, New Delhi, India, 20–24 November 2015.
4. Thaikua, S.; Chanpeng, P.; Juntasin, W.; Donsawai, S.; Chuchua, P.; Kouki, K.; Kawamoto, Y. Effect of ploidy on digestibility and fiber fraction of ruzigrass (*Brachiaria ruziziensis*). In Proceedings of the 18th Asian–Australasian Animal Production (AAAP) Congress, Sarawak, Malaysia, 1–5 August 2018; p. 434.
5. Hare, M.D.; Pizarro, E.A.; Phengphet, S.; Songsiri, T.; Sutin, N. Evaluation of new hybrid *Brachiaria* lines in Thailand. 2. Seed production. *Trop. Grassl.-Forrajes* **2015**, *3*, 94–103. [[CrossRef](#)]
6. West, S.H.; Pitman, W.D. Seed production technology of tropical forages. In *Tropical Forage Plants, Development and Use*; Sotomayor-Rios, A., Pitman, W.D., Eds.; CRC Press: Boca Raton, FL, USA, 2001; pp. 143–166.
7. Benaseer, S.; Masilamani, P.; Alex Albert, V.; Govindaraj, M.; Selvaraju, P.; Bhaskaran, M. Impact of harvesting and threshing methods on seed quality—A review. *Agric. Rev.* **2018**, *39*, 183–192.
8. Loch, D.S.; de Souza, F.H. Seed harvesting and drying: Grasses. In *Forage Seed Production. Volume 2: Tropical and Subtropical Species*; Loch, D.S., Ferguson, J.E., Eds.; CAB International Publishing: Wallingford, UK, 1999; pp. 191–212.
9. Hare, M.D.; Tatsapong, S.; Saiprasert, K. Seed production of two *brachiaria* hybrid cultivars in north-east Thailand. 2. Closing date defoliation. *Trop. Grassl.* **2007**, *41*, 35–42.
10. Phaikaew, C.; Pholsen, P. Ruzigrass (*Brachiaria ruziziensis*) seed production and research in Thailand. In Proceedings of the Third Meeting of Regional Working Group on Grazing and Feed Resources of Southeast Asia, Khon Kaen, Thailand, 31 January–6 February 1993; pp. 165–173.

11. Phaikaew, C.; Pholsen, P.; Chinosang, W. *Effect of Harvesting Methods on Seed Yield and Quality of Purple Guinea Grass (Panicum maximum TD.58) Produced by Small Farmers in Khon Kaen, Annual Report*; Bureau of Animal Nutrition Development, Department of Livestock Development: Bangkok, Thailand, 1995; pp. 103–108.
12. Phaikaew, C.; Poonpipat, W.; Nakmanee, G.; Chinosang, W.; Sooksaran, W. *Effect of Harvesting Methods on Seed Yield and Seed Quality of Panicum maximum cv. Mombaza, Annual Report*; Bureau of Animal Nutrition Development, Department of Livestock Development: Bangkok, Thailand, 2010; pp. 194–204.
13. Kamphayae, S.; Lertrattanapong, B.; Suksaket, A.; Pholsen, P. *Effects of Plant Spacing and Harvesting Method on Seed Yield and Seed Quality of Umaku Guinea Grass (Panicum maximum cv. Umaku)*; Annual Report; Bureau of Animal Nutrition Development, Department of Livestock Development: Bangkok, Thailand, 2013; pp. 309–319.
14. LDD (Land Development Department). 2009. Available online: http://oss101.ddd.go.th/osr_data&service/OSR_PDF/TB_SSK_Distribute/P_SSK529.pdf (accessed on 26 December 2023).
15. LDD (Land Development Department). 2010. Available online: <https://www.ddd.go.th/PMQA/2553/Manual/OSD-03.pdf> (accessed on 26 December 2023).
16. ISTA. *International Rules for Seed Testing Edition 2011*; The International Seed Testing Association (ISTA): Bassersdorf, Switzerland, 2011.
17. R Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2020.
18. Rao, I.M.; Kerridge, P.C.; Macedo, M. Nutritional requirements of *Brachiaria* and adaptation to acid soils. In *Brachiaria: Biology, Agronomy, and Improvement*; Miles, J.W., Maass, B.L., do Valle, C.B., Eds.; Centro Internacional de Agricultura Tropical (CIAT), International Center for Tropical Agriculture: Cali, Colombia, 1996; pp. 53–71.
19. Boonman, J.G. Determinants of seed yield. In *On the Seed Production of Tropical Grasses in Kenya*; Leniger, H.A., Ed.; Centre for Agricultural Publishing and Documentation: Wageningen, The Netherlands, 1973; pp. 2–9.
20. Stür, W.W.; Hopkinson, J.M.; Chen, C.P. Regional experience with *Brachiaria*: Asia, the South Pacific, and Australia. In *Brachiaria: Biology, Agronomy, and Improvement*; Miles, J.W., Maass, B.L., do Valle, C.B., Eds.; Centro Internacional de Agricultura Tropical (CIAT), International Center for Tropical Agriculture: Cali, Colombia, 1996; pp. 258–271.
21. Kendrick, C. *Brachiaria* hybrid. In *Pastures Australia*. 2008. Available online: https://keys.lucidcentral.org/keys/v3/pastures/Html/Brachiaria_hybrid.htm (accessed on 26 December 2023).
22. Bouathong, C.; Hare, M.D.; Losirikul, M.; Wongpichet, K. Effect of nitrogen-rates on plant growth, seed yield and seed quality of three lines of *Brachiaria* hybrid grass. *Khon Kaen Agric. J.* **2011**, *39*, 295–306.
23. Nadew, B.B. Effects of climatic and agronomic factors on yield and quality of bread wheat (*Triticum aestivum* L.) Seed: A review on selected factors. *Adv. Crop. Sci. Tech.* **2018**, *6*, 356.
24. Wongsuwan, N. Seed Production Studies in Ruzi Grass (*Brachiaria ruziziensis* Germain and Everard). Master's Thesis, Massey University, Palmerston North, New Zealand, 1994.
25. Ison, R.L.; Hopkinson, J.M. Pasture legumes and grasses of warm climate regions. In *CRC Handbook of Flowering*; Halevy, A.H., Ed.; CRC Press: Boca Raton, FL, USA, 1985; Volume 1, pp. 203–251.
26. Hopkinson, J.M.; de Souza, F.H.D.; Diulgheroff, S.; Ortiz, A.; Sánchez, M. Reproductive physiology, seed production and seed quality of *Brachiaria*. In *Brachiaria: Biology, Agronomy, and Improvement*; Miles, J.W., Maass, B.L., do Valle, C.B., Eds.; Centro Internacional de Agricultura Tropical (CIAT), International Center for Tropical Agriculture: Cali, Colombia, 1996; pp. 124–140.
27. Delouche, J.C. Environmental effects on seed development and seed quality. *Hortic. Sci.* **1980**, *15*, 13–18. [[CrossRef](#)]
28. Chastain, T.G. *Pollination and Seed Yield in Grass Seed Crops*; Oregon State University: Corvallis, OR, USA, 2013; Available online: <https://osu-wams-blogs-uploads.s3.amazonaws.com/blogs.dir/873/files/2013/06/Pollination-and-Seed-Yield.pdf> (accessed on 26 December 2023).
29. Phunphiphat, R.; Phaikaew, C.; Phunphiphat, W.; Nakmanee, G. *Brachiaria Hybrids Regional Adaptability Test. 2. Yield and Chemical Composition of Herbage, Seed Yield and Seed Quality of Mulato, Mulato II and Ruzi Grass at Lampang, Annual Report*; Bureau of Animal Nutrition Development, Department of Livestock Development: Bangkok, Thailand, 2007; pp. 234–244.
30. Nakmanee, G.; Phaikaew, C.; Thinnakorn, S.; Kruemangkorn, P. *Brachiaria Hybrids Regional Ability Test 1. Yield and Chemical Composition of Herbage, Seed Yield and Seed Quality of Mulato I, Mulato II and Ruzi grass at Pakchong Nakhonratchasima, Annual Report*; Bureau of Animal Nutrition Development, Department of Livestock Development: Bangkok, Thailand, 2007; pp. 211–221.
31. Phaikaew, C.; Pholsen, P.; Tudsri, S.; Tsuzuki, E.; Numaguchi, H.; Ishii, Y. Maximising seed yield and seed quality of *Paspalum atratum* through choice of harvest method. *Trop. Grassl.* **2001**, *35*, 11–18.
32. Kowithyakorn, L.; Phaikaew, C. Harvesting and processing techniques of tropical grass and legume seeds for small farmers. In *Proceedings of the XVII International Grassland Congress, Palmerston North, New Zealand, 8–21 February 1993*; pp. 1809–1813.
33. Hare, M.D.; Wongpichet, K.; Tatsapong, S.; Narksombat, S.; Saengkhum, M. Method of seed harvest, closing date and height of closing cut affect seed yield and seed yield components in *Paspalum atratum* in Thailand. *Trop. Grassl.* **1999**, *33*, 82–90.
34. Gelderman, R.; Carson, P.; Gerwing, J. Fertilizing for grass seed production. *Agric. Exp. Stn. Circ.* **1987**, *272*. Available online: https://openprairie.sdstate.edu/cgi/viewcontent.cgi?article=1271&context=agexperimentsta_circ (accessed on 26 December 2023).

35. Wongsuwan, N.; Chu, A.C.P.; Watkin, B.R. Effects of water stress on seed production in Ruzi grass (*Brachiaria ruziziensis* Germain and Everard). In Proceedings of the XIX International Grassland Congress, São Paulo, Brazil, 11–21 February 2001.
36. Sehgal, A.; Sita, K.; Siddique, K.H.M.; Kumar, R.; Bhogireddy, S.; Varshney, R.K.; HanumanthaRao, B.; Nair, R.M.; Prasad, P.V.V.; Nayyar, H. Drought or/and heat-stress effects on seed filling in food crops: Impacts on functional biochemistry, seed yields, and nutritional quality. *Front. Plant Sci.* **2018**, *9*, 1705. [[CrossRef](#)] [[PubMed](#)]

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