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Register and Popularize of "Begna" Newly Released Durum Wheat (*Triticum turgidum L.*) Variety for Southeastern Ethiopia

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Abstract: Developing new durum wheat varieties with high yielding, quality, stress tolerant, uniform and stable is the most important of breeders goal. Benya is commercial name given to a newly released durum wheat variety originated from ICARDA. Twenty durum wheat genotypes were tested under regional variety trial along with two standard checks (Bulala and Dire) and with local check (Ingilize) for two successive years (2019 and 2021) across three environments namely; Sinana, Agarfa and Ginir representing Southeastern Ethiopia. Data analysis of yield showed that, Begna gave highest mean yield up to 4.94t ha^{-1} compared to nineteenth test entries. Moreover, Begna showed more stable grain yield performance, standard quality, disease tolerant, uniform, high protein and gluten content, high biomass and it is early maturing variety. Farmers and others stakeholders were allowed participatory variety selection and Begna is their preferred variety in the trial. Under variety verification it was evaluated both on farmers' field and research station along with Tasfaye standard check and Ingilize local check during 2021/2 cropping season. Finally Begna was officially released in 2022 for high and mid altitude of Southeastern Ethiopia. It is commercial variety and offers new hope for farmers in rust-prone regions.

Keywords: Durum Wheat, Grain Yield, Variety Release, Grain Quality, Disease Reaction

1. Introduction

Durum wheat (*Triticum durum* Desf.) is an important food crop of the world, with an estimated 36 million t of annual global production [1]. It is originated from the domesticated form of a wild species named emmer wheat (*Triticum dicoccum* Koern.) between 12,000 and 10,000 years ago, in the West Levantine [2]. A very large amount of genetic diversity exists for this crop and that diversity also extends to the many traditional ways of consuming it, including several unique dishes that represent with pride the national identities: pasta, couscous, bourghul, freekeh, gofio and unleavened breads, just to name a few [3]. Regardless of its tight connection to the dishes of the tradition, durum wheat today is cultivated in developed countries mainly as a cash crop to feed the booming food industry. Also in Ethiopia durum wheat is commercial crop and the demand for this crop is increasing from time to time because of the emerging agro-processing industries particularly for pasta and macaroni processing. It must be mentioned that the pasta industry in SSA often utilizes bread wheat flour for its production and typically only products from North Africa and developed countries meet the international standard definition of 'pasta' by using 100% durum semolina [4].

In sub-Saharan Africa (SSA), Ethiopia is the largest producer of durum wheat, with approximately 0.6 million ha [5]. Total area dedicated to durum wheat in Sab-Saharan Africa (SSA) is limited to 630,000 ha, of which 90% it is cultivated in Ethiopia but, clearly, there is huge agricultural and commercial scope for expanding domestic production of durum wheat in SSA countries [6].

Durum wheat breeding is considered to be one of the most cost effective and environmentally safe ways to meet the future challenges that durum wheat productivity will face due to climate change. High level of durum wheat resistance to rust than bread wheat is one of the most visually decision

points for farmers to adopt durum wheat variety [7]. Southeastern Ethiopia is characterized as high rainfall areas where rust disease is the bottle neck for durum wheat production. Due to high disease pressure, only a number of varieties are in the production and the region is face a range of factors spanning biotic stresses that impact yields and quality specifications desired by end-users. So, durum wheat breeding programs must be even more efficient in Ethiopia due to the upcoming climate change effects, increased food demands and emerging agro-processing industries. A high yield, good end-use traits, and resistance to abiotic and biotic stresses have always been targets for wheat breeders. The objective of this study therefore, to register and popularize newly released durum wheat variety for mid and highland altitude of Southeastern Ethiopia.

2. Materials and Methodologies

Twenty durum wheat lines International Center for Agricultural Research in the Dry Areas (ICARDA) origin were tested under regional variety trial for two consecutive years at three environments namely; Sinana, Agarfa and Ginir in 2019-2021. The field experiment was laid out in randomized complete block design with three replications. Lastly, two lines as candidate (DZARCON-17 plt#2 and DZARCON-17 plt#11) were selected and verified at multi locations along with two checks; Tasfaye and Ingilize due to significantly better mean grain yield, good quality and tolerant to wheat rust (stem rust and yellow rust) diseases. Both candidates were verified during 2022 main cropping season at four environments (Sinana, Agarfa, Gololcha and Ginir) using none replicated 10m x 10m plot design. All study environments are characterized by bi-modal rainfall pattern. Seeding and fertilizer rates 150 kg/ha and 200/100 kg/ha (UREA/NPS (B)) were applied respectively. Whereas; UREA (N) was applied in split application form where $1/3^{rd}$ was applied at planting time and the remaining $2/3^{rd}$ was applied at tillering stage as per agronomic recommendation. Planting was done by hand drilling; weed was controlled by using hand weeding and as well as by using herbicide called Pallas 45OD at the recommended rate and time of application.

3. Varietal Origin and Evaluations

The combined analysis of variance across three environments revealed significant genotypic differences for all traits measured except for days to heading. Begna is a commercial name given for a newly released durum wheat variety with the pedigree name DZARCON-17 plt#2 which originated from International Center for Agricultural Research in the Dry Areas (ICARDA). As Begna out yield and well performed, it was advanced to a regional variety trial to be tested across wide locations over years for further evaluation. Combined analysis revealed that it had produced an average yield of 4.12 t ha^{-1} (Table 2). Due to consistently out-yielded and stress tolerant over locations and years, Begna was verified at four locations three sites at each during 2022 for official release. Consequently, Begna showed superior agronomic performances over the standard check Tasfaye and the local check Ingilize at all studied environments. Participatory plant selection (PPS) was incorporated that includes the involvement of end users and farmers in the selection process. Plant breeders contribute their expertise in creating genetic variation, in population management and in designing screening methods that can separate genetic from environmental effects and participation provides flexibility in the selection program [8]. Finally, Begna decided to release after being evaluated by the National Variety Releasing Committee (NVRC), for the mid and highlands of Southeastern Ethiopia. After genotype "DZARCON-17plt#2" decided by National Variety Release Committee (NVRC) Begna name was given for newly released durum wheat variety.

4. Result and Discussion

4.1. Morphological Description of Variety

Table 1. *Agronomic and morphological characteristics of new durum wheat variety 'Begna'.*

1. Varietal Name	Begna
2. Adaptation area	2a. Mid and high lands of Bale; Sinana, Agarfa and Ginir 2b. Altitude (m.a.s.l): 1700-2509 2c. Rainfall ranges from: 750-1500mm Temperature ranges from: 9.5°C – 21°C
3. Seed rate	150kg
4. Fertilizer rate	4a. NPS = 100 4b. UREA = 200 4c. UREA in split application = $1/3^{rd}$ at planting and $2/3^{rd}$ at tillering
5. Planting date	Mid-August to early September based on-set of rainfall
6. Days to heading	68
7. Days to mature	136
8. Plant height	86cm
9. Growth habit	Erect
10. Ear type	Slightly compact
11. Thousand kernel weight	45.1
12. Seed color	Amber
13. Hectoliter weight	83.4 Kg/L
14. Crop pest reaction	Tolerant to major wheat diseases
15. Yield (t ha^{-1})	15a. Research field: 3.90 – 4.45t ha^{-1} 15b. Farmers field: 3.57 – 4.95t ha^{-1}
16. Quality parameters	16a. Protein = 15.4 16b. Gluten = 30.3
17. Breeder/Maintainer	SARC/IQQO
18. Spike density	Very dense
19. Flag leaf and stem color	Glucocity
20. Awns attitude	Medium
21. Glumes color	White
22. Auricle color	Slightly purple
23. Seed size	Large
24. Seed shape	Moderately elongated
25. Year of release	2022

Begna is commercial variety selected from ICARDA and released as an alternative variety to Bulala and Dire. Traits like days from emergence to heading (DH) and mature (DM) through periodic observations (twice per week) were

recorded, when approximately half of the spikes in the plot had already extruded and seventy five percent (75%) of plants in the plot reach maturity stage respectively. Begna variety is early mature which allows avoiding sudden terminal drought especially at low land/low moisture areas. It is relatively shorter in height than checks which; is fit for mechanization. Begna has better disease tolerant, high test weight, good plant stand and tillering capacity, erected growth habit of stem and leaf, slightly compact head type, amber seed color, waxy leaf, it is stable, uniform, has strong stalk, frost tolerant, lodging resistance, high germination capacity and has no shattering problem. Moreover, other characteristics of the variety described in the following Table (Table 1).

Table 2. *Mean agronomic performance and disease reactions of 20 durum wheat genotypes tested in durum wheat regional variety trial (DWRVT-19) combined over locations and years (2019_2020).*

SNo.	Pedigree	Agronomic Traits						Disease Score		
		DH	DM	PLH	GYLD (t ha^{-1})	TKW	HLW	YR	SR	LR
1	DZARCON-17plt#1	67	123.8	79.3	1.54	24.8	79.1	5ms	80s	r
2	DZARCON-1717plt#2	68	126	78.9	4.12	39.6	82.1	10ms	5ms	r
3	DZARCON-1717plt#3	67	125	76.6	3.01	35.7	80.3	2ms	15s	r
4	DZARCON-1717plt#4	67	124	71.6	2.49	29.5	78.7	5ms	60s	r
5	DZARCON-1717plt#5	67	124	76.0	2.67	28.1	79.2	trms	60s	trms
6	DZARCON-1717plt#6	70	127	79.4	2.85	42.5	80.7	25s	20s	r
7	DZARCON-1717plt#7	67	125	79.7	3.33	39.1	82.9	trms	30s	r
8	DZARCON-1717plt#8	66	123	80.4	3.25	38.7	81.6	15ms	25s	trms
9	DZARCON-1717plt#9	69	125	80.6	3.25	42.0	82.3	10ms	20s	r
10	DZARCON-1717plt#10	67	123	77.9	3.02	38.7	80.5	5ms	30s	r
11	DZARCON-17 17plt#11	67	125	80.3	4.07	45.5	83.1	5ms	5ms	r
12	DZARCON-1717plt#12	69	128	81.3	3.55	43.2	82.3	15s	25s	r
13	DZARCON-1717plt#13	69	120	79.1	3.07	43.0	81.1	20s	10s	r
14	DZARCON-1717plt#14	65	123	76.5	2.96	38.6	82.0	15s	20s	r
15	DZARCON-1717plt#15	68	126	82.4	3.18	40.2	82.9	15s	30s	trms
16	DZARCON-1717plt#16	66	124	78.6	3.06	40.8	78.7	10ms	70s	r
17	DZARCON-1717plt#17	67	123	76.8	1.58	26.5	74.9	5ms	80s	r
18	Dire	68	125	77.2	3.25	31.1	82.1	20s	25s	r
19	Bulala (standard check)	65	123	80.0	3.16	40.3	80.2	10s	15s	r
20	Englize (local check)	65	125	106.7	3.25	41.2	81.6	20s	20s	r
Mean		67**	124^{ns}	80.0**	3.03**	37.4**	80.8**			
CV (%)		3.3	5.8	6.8	24.9	12.8	5.1			
LSD (5%)		1.5	4.7	3.6	489.7	3.1	2.7			

Where:- DH: days for heading, DM: days to maturity, PLH: plant height (cm), TKW: thousand kernel weight (cm), HW: test weight (kg/hl), GYLD: grain yield (kg/ha), SR: stem rust (%), YR: yellow rust (%), LR: leaf rust (%), S: Susceptible, MS: moderately susceptible, Mr: Moderately resistant, Trms: Trace with moderately susceptible, Trmr: Trace with moderately resistant, R: Resistant, CV (%): Coefficient of variations, SE: standard error of the mean, LSD: Least significant differences, ns: non-significant differences, ** significantly different from each other based on the 0.05 probability level of LSD, t: ton, ha: hector

4.2. Yield Performance

The yield performance of the genotypes across environments averaged ranged from 3.57-4.94t ha^{-1}. The highest overall grain mean recorded for Begna was 4.94t ha^{-1} and lower yield was recorded for standard checks Bulala and Dire were 3.16 and 3.25t ha^{-1} respectively. Similarly, the lower grain yield was recorded for local check Ingilize 3.25t ha^{-1} among the tested entries (Table 2). Also as indicated in Table 3 the yield advantage of Begna over standard check Bulala is 30.6% and 27.3% over the local check Engilize.

Table 3. *Annex statistical analysis of yield data (year, location and year x location).*

Year	Location	Error mean square (EMS)	Total yield of Begna (t ha^{-1})	Percent of Benya over check (Bulala)	Percent of Begna over check (Ingilize)
2019	Ginir	274473.76	3.98	25.5	40.7
	Sinana	423490.81	4.45	23.4	40.7
	Agarfa	296626.69	3.57	40.4	7.1
2020	Ginir	867745.42	4.94	43.5	45.4
	Sinana	365750.25	3.90	30.6	9.2
	Agarfa	492377.62	3.91	20.4	21.1

Where:- EMS: Error mean square, t: ton, ha: hector

4.3. Quality Characteristics

Begna identified as highly productive and resistant to prevailing diseases in the Bale zone and with good gluten strength. As compared to the candidates and the checks Begna was the best variety with protein content of 15.4% and gluten

content 33.3% that require industry standards (Table 4). Also it has high thousand kernel weight (45.1g) and test weight (83.9 kg/L) (Table 4). Its seed color is amber which is preferred by consumers. The durum wheat breeding programs carried out over the 20th century mainly focused on increasing yield in combination with quality characteristics for pasta products [9-12].

Table 4. *Mean agronomic performance and quality parameters of verified candidates over locations.*

No	Genotypes	Agronomic traits				Disease scored			Quality traits			
		Dh	DM	Plh	Gy t ha^{-1}	SR	YR	LR	Gluten	Protein	TKW	TW
1	Begna	60	129	80.0	4.94	trms	5ms	0	33.3	15.4	45.1	83.9
2	Tasfaye	63	130	85.2	35.7	15ms	15ms	0	27.0	13.8	33.3	83.8
3	DZARCON-17 plt#11	58	128	75.7	38.0	trms	trms	15ms	30.3	14.3	47.8	83.7
4	Ingilize	57	127	107.3	33.5	5ms	10ms	5ms	30.4	14.5	43.3	82.9

Note: Dh: days for heading, Dm: days to maturity, Plh: plant height, TKW: thousand kernel weight, TKW: test weight, Gy: grain yield, Sr: stem rust, Yr: yellow rust, Lr: leaf rust, S: Susceptible, MS: moderately susceptible, Mr: Moderately resistant, Tr, trace, Trms: Trace with moderately susceptible, ha: hector, t: ton

4.4. Disease Reaction

The major durum wheat disease according to their importance in the growing area is rust (YR, SR and LR). For rust diseases the modified Cobb's scale was applied and disease data over locations were scored and analyzed. Accordingly, Benya scored 10ms (%) for yellow rust and 5ms (%) for stem rust which makes it tolerant to rust disease (Table 2). The variety response is moderately resistance for yellow rust and stem rust. Generally, Begna variety is tolerant to disease (stem rust, yellow rust and leaf rust) and other abiotic factors.

4.5. Adaptation and Agronomic Recommendations

Newly released durum wheat variety, Begna is recommended for Sinana, Agarfa, Gololcha, Ginir and for similar agro-ecologies. It performs very well at altitude ranging from 1700-2509 m.a.s.l. and receiving annual rainfall of 750 -1500mm areas. The seed and fertilizer rates recommended for Begna variety is 150 kg/ha and 200/100 kg/ha (UREA/NPS) respectively. Fertilizer (UREA) application is in split form where; 1/3rd applied at planting and the remaining 2/3rd applied at tillering stage. Based on-set of rain fall planting time ranging from mid-August to early September. Favorable growing temperature ranges from 10°C – 21°C through crop growing stages which, is optimum temperature for wheat production areas. The optimum growing temperature for wheat during pollination and grain filling phases is 21°C [13, 14] and for each increase of 1°C above it is estimated a decline of 4.1% to 6.4% in yield [15].

4.6. Variety Maintenance

The variety is maintained under the responsibility of breeder and foundation of the seed by Sinana Agricultural Research center/Oromia Agricultural Research Institute.

5. Conclusion

Today, it is recognized that agricultural production requires the adoption of environmentally friendly solutions; the release of varieties suitable for low input environments to set new goals for durum wheat breeding that align with the real needs of farmers and the market that are imprinted in Ethiopia. Begna durum wheat variety was officially released in May 2022 for its high yield, quality, stabile, uniform, better disease tolerant and wider adaptability. It yields more than 4.9t ha^{-1} and generally, released for mid to high land areas of Southeastern Ethiopia.

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