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Effect of Harvest Time on Yield and Seed Quality of Teosinte

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Abstract: Two experiments; a field and a laboratory experiment were conducted at Giza Agric. Res. station, ARC during the two successive summer seasons of 2012 and 2013 to study the effect of harvest time on germination and seed yield of teosinte. Five harvest times were studied, the first harvest time was 159 days after sowing date and then after, 166, 173, 180 and 187 days. The field was laid out in a Randomized Complete Block Design (RCBD). Plant height, number of tillers plant^{-1}, number of fruiting cluster, fresh weight plant^{-1}, grain weight plant^{-1}, 100-grain weight and grain yield kg fed^{-1} were determined for field experiment. Germination percentages, moisture in seeds, shoot length, radical length, fresh and dry seedling weight and seedling vigor index were determined for laboratory experiment. Results showed that germination percentages (79%) were increased at the third harvest time (173days after sowing) which moisture seed content 13.80%, the protein was (11.17%) in grains, 100-grain weight and grain yield were increased at this harvest time.

Key words: Teosinte (*Euchlaena maxicana* Schard) · Harvest time · Grain yield · Germination · Accelerated ageing germination · Fruiting clusters

INTRODUCTION

Teosinte or Rayyana (*Euchlaena maxicana* Schard) is one the most important summer forge crops in the world. Teosinte has survived as wild plant because the pistillate spike breaks up at maturity to disperse the kernels, which unlike maize, kernels are protected in heavy cellulose-lignin structure called fruit-cases. Fruit cases are composed of hard segments of the rachis of the spike,and lignified outer glumes,and may be black, gray with black speckles,or ivory white [1].Annual and tetraploid perennial teosinte are photoperiodic short-day plants [2].On the other hand,some investigators evidence that annual teosinte seeds are dormant when harvested and require after ripening period. Germination percentage and purity are two factors given priority in seed certification, whereas stage of seed maturity for harvest and methods of drying are among the major factors deciding seed quality [3]. Seed development occurs in the period between fertilization and maximum fresh weight at physiological maturity even through the maturation of seed commences at the end of seed crop [4]. Some knowledge about seed development and physiological maturity helps ensures seed quality in terms of germination and vigor. Seed harvested prior to attainment will be under developed and store less food reserve as compared to those harvested at physiological maturity [5]. Seed harvested at physiological maturity is a genotypic character but its attainment is also influenced by environmental factors [6, 7]. Hamilton [8] have also reported that drying harvested maize to 15.5 % moisture content or lower within 24 to 48 h reduced the risk of fungi growth and consequently aflatoxin production. Seed harvested at physiological maturity is considered to have maximum viability and vigor [9].

This investigation aimed to study the effect of harvesting stage on yield and seed quality of teosinte.

MATERIALS AND METHODS

Field Experiment: Two Field experiment were conducted at Giza Agric. Res. station, ARC, during the two successive summer season of 2012 and 2013 to study the effect of harvest time on germination and seed yield of teosinte. The physical and chemical characteristics of the experimental soil before planting were carried out according to the analytical methods described by Jackson [10].

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Five harvesting times were used. The first one was after 159 days from sowing date and then after 166,173,180 and 187 days after sowing date. The first date was 40 days after anthesis.

The preceding crop in the two seasons was Egyptian clover and sowing date was 30th and 28th May in the first and second seasons respectively. The experiment was laid out in a randomized complete block design (RCBD) with three replications and plot area was 12 m^2 consisted of five ridges with 60 cm wide and 4 m long. Grains were planted in hills 20 cm apart with 20 kg fed^{-1} seeding rate, the local variety was used. The plot unit received 22.5 kg P_2O_5 fed^{-1} at soil preparation. Nitrogen fertilizer was added at three equal doses (at rate 120 kg N fed^{-1}) in form of urea (46.5%N). Also, all plots received 25 kg K_2O fed^{-1} added at three equal doses. The first dose for nitrogen and potassium fertilizers was added after 21 days from sowing, the second and the third doses were added after the first and the second cuts, respectively. Two cuts were taken during growing seasons. The first cut was taken after sixty days from sowing and the Second cut was taken after thirty days. All other recommended treatments were applied to raise a good crop. The studied characters were plant height, number of tiller $plant^{-1}$, number of fruiting clusters, number of leaves $plant^{-1}$, fresh forage weight $plant^{-1}$, grains weight $plant^{-1}$, 100-grain weight and seed yield kg fed^{-1} (determined from the average of five randomly selected plants from each plot area for all treatments).

Laboratory Experiment: Laboratory experiment was conducted at Seed Technology Department, ARC, Giza. Seed samples were collected from each experimental plot.

Germination Test: Grains were incubated in moist filter paper at 25°c for 10 days. Normal seedlings were counted according to international rules of I.S.T.A. [11] and expressed as germination percentage, (ten seedlings were randomly selected and measured radical, shoot length and seedling fresh and dry weight according to Krishnasamy and Shesha [12].

Germination Percentage: n / N X 100. Where, n is the number of germinated seeds, N is the number of total seeds planted.

Fresh Weight and Dry Weight of Seedling: the seedling were put into paper packet separately and placed into the preheated oven dry weight was taken after 3 days at 70°C.

Moisture Content in Seeds: Moisture content in seeds was computed by the standard protocol [11].

Seedling Vigor Index: was determined according to the formula given by Reddy and Khan [13].Seedling vigor index = germination percentage X seedling length.

Protein Percentage of Seeds: Nitrogen percentage was determined in seeds using microkjeldhal methods and crude protein percentage was estimated by multiplying N% by 6.25 [14].

Accelerated Ageing Germination: The seeds were kept in an ageing chamber at 42 °C and 100% relative humidity for 92 hours. After ageing, the seeds were dried,seed survival percentage was determined by the standard germination test at 25°c and mean normal seedling percentage was calculated according to AOSA [15].

Least significant differences test was used for comparing treatments means as described by Steel and Torrie [16], using the computer program PLABSTAT (Statistical Analysis of Plant Breeding Experiments) [17]. Bartlett [18] was done to test the homogeneity of error variances. The test was non significant for all traits, thus combined analysis was carried out for all studied traits. The phenotypic correlation (r) between each pair of traits was calculated using the formula of Miller *et al.* [19].

RESULTS AND DISCUSSION

Results in Table (2) show that germination %, moisture %, shoot and radical length, fresh and dry seedling weight and seedling vigor index were significantly affected by harvest time at 5%.

Germination percentage ranged from 57 to 79%, the highest germination percentages were 79% and 72%, which there seed contained 13.80% and 11.90% moisture respectively, at the third and fourth harvest time (173 and 180 days after sowing). Teosinte seeds of good seed quality are obtained when already have germination rates of over (70%); the highest seed quality is obtained when it is harvest between 40-50 days after the anthesis [20]. Shete *et al.* [21] obtained an increase in germination % with the advancement of harvesting dates. While in case of early harvesting (159 after sowing), the germination % was decreased to 57% and seeds contained 16.70% moisture. Seed metabolic activities generally increased with temperature and moisture content simultaneously and a high moisture content reduced seed germination Owolade *et al*. [22]. Harvesting the crop earlier resulted in

Table 1: Some physical and chemical properties of soil.

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Soil texture	OM (%)	$CaCO_3$ (%)
8.32	22.83	35.72	33.90	Clay Loamy	1.19	7.54

		Cations (meq/l)				Anions (meq/l)		
pH (1:2:5)	EC (dS/m)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO^{-}_3	Cl^{-}	SO^{-}_4
7.44	2.46	9.52	2.88	23.20	0.78	1.44	10.80	16.10

Table 2: Germination %, moisture % and seedling characters of teosinte as affected by different harvest time (Combined analysis of the two growing seasons 2012 and 2013).

Dates of harvesting (after planting)	Germination (%)	Moisture (%)	Shoot length (cm)	Radical length (cm)	Fresh seedling Weight (g)	Dry seedling weight (g)
159 days	57.00	16.70	11.23	7.37	0.24	0.001
166 days	70.00	15.28	12.12	8.07	0.30	0.004
173 days	79.00	13.80	14.12	10.02	0.35	0.006
180 days	72.00	11.90	13.28	8 .22	0.31	0.005
187 days	60.00	10.58	9.33	6.12	0.17	0.001
Mean	67.60	13.65	12.02	7.90	0.27	0.003
$LSD_{0.05}$	1.65	0.18	0.20	0.16	0.003	0.001

Table 3: Seedling vigor index, protein% and accelerated ageing test of teosinte as affected by different harvest time (Combined analysis of the two growing seasons 2012 and 2013).

Dates of harvesting (after planting)	Seedling vigor index	Protein (%)	Accelerated ageing
159 days	1081.00	11.85	20
166 days	1417.00	11.45	31
173 days	1925.00	11.17	49
180 days	1584.00	10.62	29
187 days	928.66	10.13	24
Mean	1387.13	11.04	31
$LSD_{0.05}$	2.46	0.13	1.84

poor seed quality owing to immaturity [23]. Germination was higher in large sized seeds and lower in small size of groundnut [24]. Early harvesting as a means of reducing infection by field fungi minimized aflatoxin levels and obtain maximum returns [25]. On the other hand delay harvested were decreased germination percentage to 60% and seeds contained 10.58% moisture but it was better than early harvest. Robertson *et al.* [26] reported that the reduction in seed moisture content was with delaying maturity. The decrease in germination % may be due to teosinte fruit cases being closely associated with absence or poor development of embryos [27].

For shoot and radical length, the highest values were 14.12 and 10.02 cm, respectively, when harvest was done at 173 days after sowing) and seedling length from the seeds collected at 35 days after flowing which might have resulted in vigorous growth [28]. The decrease in shoot and radical length accord for early and delay harvesting. The values were 11.23 and 7.37 and 9.33 and 6.15 cm for shoot and radical length respectively. The third harvesting time (173 days after sowing) was better in fresh and dry weight of seedling; the values were 0.35 and 0.006 g followed by 0.31 and 0.005 g at the fourth harvesting date. In case of early harvesting time the fresh and dry seedling weight were decreased to 0.24 and 0.001g respectively. Crop harvested after 120 days from sowing produced low weight of seedling [29]. Fresh and dry seedling weight was decreased when harvest was delayed to (187 days from sowing). The values were 0.17 and 0.001g respectively.Dry weight decreased because of restricted supply of nutrients from mother plant to seed due to disruption of vascular connection and utilization in various physiological and metabolic processes [30].

Results in Table (3) show that seedling vigor index, protein percentage and accelerated ageing were significantly affected by harvesting date. The highest seedling vigor index was 1925.00 when harvest was done after 173 days from sowing followed by 1584.00 at the fourth harvest time. Increased seed vigor index might be due to maturation of seeds resulting in improvement of germination percentage and seedling length [31]. In case of early and delay harvesting, seedling vigor index was decreased to 1081.00 and 928.66, respectively. Harvesting

the seeds before the attainment of physiological maturity recorded loss of viability and vigor potentials due to more number of immature seeds with relatively low degree of embryo development and high moisture content [7]. The protein % were increased at earliest harvesting date after 159 days from sowing, the value was 11.85%. This result agreed with Gaile [32] and decreased with delaying harvest, 11.45% at the second date followed by 11.17% at the third date. Protein percentage was very decreased when harvesting delayed. The values were 10.60% and 10.13% at fourth and fifth harvest time respectively. The decrease in protein is accompanied by an increase of starch and energy content [33].

A high reduction in accelerated aging germination % was (20%) under early harvest date (159 day after sowing). While the highest value was (49.0%) under the third harvest date (173 day after sowing) and it was (31%) when harvest was done 166 day after sowing. Also when harvest was delayed the germination is in Table 2 was decreased (24%) when harvest was done 187 day after sowing. Yoshida [34] stated that temperature change the rate of growth but not the efficiency while Roberts [3] found that sever damage to seed during ageing led to reduced vigor and production of abnormal seedling.

Results in Table (4) reveled that plant height, number of tillers plant^{-1}, number of fruiting clusters, number of leaves plant$^{-1,}$ fresh weight plant^{-1}, grains weight plant^{-1}, 100-grain weight and grain yield were significantly affected by harvesting time.

The highest values of plant height were 157.50 cm recorded when harvesting was done after 173 days from sowing followed by 153.33 cm recorded when harvest was after 166 days from sowing while the lowest value of 133.33 cm at the early harvesting time. The Third time of harvesting produced the highest number of tillers plant^{-1} (9 tillers) followed by (7 tillers) tillers when harvesting was done after 166 days from sowing.

The highest values of number of fruiting clusters 10.33 was recorded when harvested at 180 days after sowing, while decreased when harvested at 187 days after planting; The value was (6.33).

Teosinte plants gave the highest number of leaves plant^{-1} (17.0 leaves) and the highest fresh weight plant^{-1} (2.9 kg). At harvesting after 173 days from sowing, delaying harvest to after 187 days from sowing decreased these two traits to 12.0 leaves and 1.6 kg, respectively.

The early harvesting time decreased grains weight plant^{-1}, 100-grain weight and grain yield; the values were 89.61 g, 7.60 g and 755.77 kg fed^{-1}, respectively. The highest values 191.67 g, 12.50 g and 983.33 kg/fed recorded when harvesting plants after 173 days from sowing. Grains contained 13.80% moisture and the germination percentage was highest at the harvest time (79%). These results were in agreement with Sardana *et al.* [35]. Delayed harvest beyond physiological maturity ; to better development of kernel due to transfer of assimilates from plant parts to kernels for longer period and extra time available of development of kernels resulting in higher 100 kernel weight [29, 36].

Correlations: Results in Table (5) show a positive and high significant correlation (r=0.966**) between number of tillers and seedling vigor index, positive correlation (r=0.957*) between germination percentage and seedling vigor index. A high positive correlation (r=0.962**), (r=0.985**) and (r=0.961**) occurred between seedling vigor index and moisture and shoot length and seedling dry weight respectively. Vigor of the seeds is related to moisture content which affects the germination traits leading to higher pace of germination improving seedling growth in terms of seedling length and dry matter. Gore *et al.* [31] has attributed higher seed vigor index II probably due to associative effect of germination percentage and seedling length. Positive and high correlation (0.978**) was found between grain yield and weight of grains plant^{-1}, (r=995**) between protein percentage and seedling dry weight. Positive correlations of (r=0.902*), (r=0.951*), (r=0.882*), (r=0.929*) and (r=0.928*) occurred between number of tillers plant^{-1} and fresh weight plant^{-1}, germination %, moisture %, shoot length and fresh seedling weight, respectively. A positive and a high significant correlation (r=0.979**), (r=0.977**),

Table 4: Yield and yield component of teosinte as affected by harvesting time (Combined analysis of the two growing seasons 2012 and 2013).

Dates of harvesting (after planting)	Plan height (cm)	Number of tillers plant^{-1}	Number of fruiting clusters	Number of leaves plant^{-1}	Fresh weight, Kg plant^{-1}	Grains weight, g plant^{-1}	100-grain weight, g	Grain yield, kg fed^{-1}
159 days	133.33	6.00	7.33	16.00	1.79	89.61	7.60	755.77
166 days	153.33	7.00	8.00	15.00	1.70	127.67	9.21	784.77
173 days	157.50	9.00	10.00	17.00	2.91	191.67	12.50	983.33
180 days	145.33	6.00	10.33	16.00	1.68	181.67	12.30	900.33
187 days	143.00	6.00	6.33	12.00	1.56	133.00	11.50	796.67
Mean	146.50	6.80	8.40	15.20	1.93	144.72	10.62	844.17
LSD $_{0.05}$	13.95	1.54	2.07	1.28	0.31	23.79	0.69	103.12

Table 5: Simple phenotypic correlation coefficients among different traits of teosinte over the two growing seasons 2012 and 2013.

Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1																
2	0.433															
3	0.194	0.563														
4	0.331	0.414	0.768													
5	0.746	0.902*	0.504	0.560												
6	0.009	0.454	0.813	0.252	0.442											
7	0.089	0.088	0.869	0.626	0.035	0.755										
8	0.104	0.091	0.298	0.367	0.139	0.978**	0.371									
9	0.142	0.921*	0.611	0.404	0.746	0.530	0.196	0.135								
10	0.377	0.882*	0.503	0.653	0.876	0.144	0.057	0.359	0.852							
11	0.412	0.929*	0.626	0.680	0.906*	0.308	0.183	0.208	0.897*	0.984**						
12	0.090	0.789	0.784	0.310	0.544	0.889	0.519	0.587	0.855	0.523	0.648					
13	0.092	0.928*	0.617	0.454	0.723	0.491	0.213	0.061	0.995**	0.874	0.909*	0.822				
14	0.120	0.059	0.042	0.585	0.266	0.603	0.152	0.965**	0.040	0.516	0.390	0.391	0.121			
15	0.333	0.966**	0.606	0.568	0.876	0.376	0.153	0.093	0.957*	0.962**	0.985**	0.729	0.961**	0.269		
16	0.166	0.125	0.049	0.656	0.334	0.530	0.083	0.938*	0.102	0.573	0.458	0.316	0.182	0.995**	0.334	
17	0.130	0.979**	0.671	0.424	0.822	0.608	0.244	0.227	0.977**	0.827	0.896**	0.893**	0.955**	0.049	0.948*	0.023

*and ** Significant phenotypic correlation at 0.05 and 0.01 levels of probability, respectively.

Plant height (1), number of tillers (2),number of fruiting clusters (3), number of leaves (4), fresh weight plant^{-1} (5), grain weight plant^{-1} (6), grain yield kg fed^{-1}(7),100-grain weight (8). Germination% (9), moisture (10), shoot length (11), radical length (12), fresh seedling weight (13), dry seedling weight (14), seedling vigor index (15), protein % (16) and accelerated aging (17).

(r=0.896**), (r=0.893**), (r=0.955**) and (r=0.948**) observed between accelerated ageing and number of tillers plant^{-1}. Germination percentage, shoot length, radical length, fresh seedling weight and protein percent, respectively.

CONCLUSION

It is preferable to harvest teosinte plants after 173 days from planting to get seed for re cultivation. That is due to high grain germination percentage and the tolerance to heat stress in the selection of ageing as well as high protein percentage. Considering that delaying harvest to 187 days after sowing decreased yield due to grain shattering.

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