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# Response of groundnut (*Arachis hypogaea* L.) genotypes to combined application of phosphorus and foliar zinc fertilizers in Central Tigray, Ethiopia

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## Abstract

**Background:** Adequate phosphorus (P) and foliar zinc (Zn) in groundnut required for obtaining Zn-enriched grain and optimum yield. However, it was very low in the area. Due to that objective of the study was to investigate the response of groundnut genotypes to combined application of phosphorus and zinc on yield and nutritional contents. A field experiment was conducted at Sheka-Tekli in 2017/18 cropping season.

**Methods:** The treatments were consisted of three groundnut genotypes (ICGV00308, ICGV91114 and Sedi) as main plot and four combined PZn fertilizer levels (00), 10 kg P/ha + 0.50 g Zn/L, 20 kg P/ha + 1 g Zn/L and 30 kg P/ha + 1.5 g Zn/L as sub plot were assigned in split plot design with tree replications.

**Result:** The result indicated that yield and yield components respond significantly to the main and interaction effects. The highest significant seed yield (2529 kg/ha) and protein content (37.79%) were obtained in response to the application of P<sub>30</sub>Zn<sub>1.5</sub> fertilizer on sedi variety in the loamy sand soil. The percentage of crude protein and fat content had significantly affected by interaction components. Most of the yield component traits showed strong positive correlation with seed yield. While the lowest seed yield was recorded from ICGV00308 without fertilizer. The highest fat content (43.95%) was gained from genotype ICGV00308 at P<sub>30</sub>Zn<sub>1.5</sub> fertilizer. From the interaction of sedi with P<sub>30</sub>Zn<sub>1.5</sub> fertilizer was recorded highest protein content. Based on economic analysis the highest MRR (380.58%) was obtained from ICGV00308 genotype at P<sub>10</sub>Zn<sub>0.5</sub> fertilizer.

**Conclusion:** From the result of the study, application of PZn fertilizer increases seed yield of groundnut. Therefore, based on the MRR result ICGV00308 genotype at P<sub>10</sub>Zn<sub>0.5</sub> fertilizer was optimum for groundnut production in the study area and similar agro-ecologies.

**Keywords:** Groundnut genotypes, P, Foliar spraying Zn, Sheka-Tekli

## Background

Groundnut (*Arachis hypogaea* L.), also known as peanut, earthnut, monkey-nut is a self-pollinating, indeterminate, annual herbaceous crop (Adinya et al. 2010). Its seed contain about 50% of edible oil and the remaining

50% of the seed has high quality protein (36.4%), carbohydrate in the range (6–24.9%), minerals and vitamin (Baraker et al. 2017).

Ethiopia retains varying climatic conditions results in the cultivation of a wide range oil crops including groundnut. Groundnut was introduced to Ethiopia in the early 1920s from Eritrea to Hararghe by the Italian travelers (Daniel 2009). Presently it accounts 13.64% of total oil seed produced.

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The lowland areas of Ethiopia have great potential for increased oil crop production including groundnut. Groundnut is one of the five widely cultivated oil seed crops in Ethiopia. It uses for oil extraction, makes important cash income for several small-scale producers and foreign exchange earnings through export for the country (Gezahagn 2013). The estimated production area and yield of groundnut in Ethiopia in 2015/2016 cropping season were 75,255.73 ha and 1151,800.37 quintals, respectively (CSA 2014).

In Tanqua-Abergelle district, Low macro and micro-nutrients, moisture, lack of improved varieties and poor agronomic practices are considered as major constraints of groundnut yield. Despite the indicated challenges through application of good management practices, the potential for increasing productivity and enhancing quality of groundnut in the region and specifically at the study area (Sheka-Tekli) is high; such as using improved varieties and through correcting essential deficient soil nutrients such as phosphorus and zinc. For example, studies made in Egypt showed that application of P-fertilizer and foliar spray of Zn in a poor soil significantly improved seed yield and quality contents (oil and protein %), Gobarah et al. (2006) and Dordas (2008) also demonstrated the role of P in improving host-resistances and toxicity of Zn to several pathogens, respectively. These justifies the need to investigate and understand how the different groundnut genotypes were interact to the combined rates of P and Zn fertilizers on yield, nutritional content and profitability of groundnut production.

## Materials and methods

In Tanqua-Abergelle district: Low macro and micronutrients, moisture, lack of improved varieties and poor agronomic practices are considered as major constraints of groundnut yield.

The study area (Sheka-Tekli) is considered as one of the most important places in Tanqua-Abergelle district, Tigray Region (Northern Ethiopia) for the production of groundnut. The study area lies between a latitude of 13° 33' 08" N, longitudes 39° 02' 8" E and elevation of 1516 m, respectively. The climate and weather conditions of Tanqua-Abergelle district belong to the sub-tropics and monsoon weather prevails throughout the year. The mean annual rainfall of the area is varying from 350 mm to 700 mm with minimum and maximum temperature of 24 °C and 41 °C, respectively.

Pre-planting soil samples was collected from five spots from the experimental field before planting diagonally at a depth of 0–30 cm (which is the estimated root depth of groundnut) using an auger. The composite sample was prepared by mixing all the sample had subjected to selected physicochemical properties.

Mainly: texture of the soil by hydrometer (Bouyoucos 1962), soil pH by pH meter (Rhoades 1982), electrical conductivity by 1:2.5 water suspension, total nitrogen by Kjeldahl, (Bremner and Mulvaney 1982), available phosphorus by Olsen method, (Olsen et al. 1954), organic carbon (Walkley and Black 1934) by volumetric, cation exchange capacity by ammonium acetate method were analyzed in Mekelle soil laboratory and available Zn by atomic absorption spectrophotometer at ezana analytical laboratory are given in (Table 1). The groundnut genotypes: ICGV00308, ICGV91114 and Sedi (standard check) were used for planting materials.

Fertilizer treatment phosphorus as triple super phosphate (TSP) and zinc sulphate ( $ZnSO_4 \cdot 7H_2O$ ) was used as a source of P and Zn fertilizer, respectively. The phosphorus fertilizer was applied in the soil at time of sowing. Whereas, foliar sparing with zinc was done at flowering stage with the rate of 952 L/ha of water (Gobarah et al. 2006).

The experimental design was split plot with groundnut genotypes (ICGV00308, ICGV9111, and Sedi main plot and four combination of (P + Zn) fertilizers ( $P_0Zn_0$ , (10 kg P/ha + 0.50 g Zn/L( $P_{10}Zn_{0.5}$ ), 20 kg P/ha + 1 g Zn/L( $P_{20}Zn_1$ ) and 30 kg P/ha + 1.5 g Zn/L) ( $P_{30}Zn_{1.5}$ ) subplot with three replications. The plot size was (1.8 × 2 m), having 45 cm distance between rows and 20 cm between plants and 15 kg per ha of nitrogen fertilizer was applied uniformly to all treatments as starter.

Agronomic data including seed yield, days to 50% flowering, 50% maturity, number of pods per plant, pod yield, number of seeds per pod and 100 seed weight (g), were collected following standard procedures. The data were analysis using GenStat 14th Edition statistical package (Payne 2014). Means were compared with Duncan's Multiple Range Tests at 5% level. Bivariate correlation was used to test the relationship between the traits of groundnut. Sample of a seed for analysis of nutritional content of the seed (crud protein and fat content %) was taken from the seed yield per plot to analysis according to AOAC (1995). Partial budget analysis of groundnut were conducted following International Maize and Wheat Improvement Center (CIMMYT) manual (CIMMYT 1988).

**Table 1** Description of the genotypes used in the study

Genotypes	Status	Source	Color
ICGV00308 (G <sub>1</sub> )	Advanced line	ICRISAT-Mali	Light white
ICGV91114 (G <sub>1</sub> )	Advanced line	ICRISAT-Mali	Light white
Standard check (sedi)	Released variety	Melka-Werer ARC	Light red

## Result and discussion

### Selected physicochemical properties of the study site

The soil texture of the experimental area was appeared to be loamy sand (Table 2). Therefore, the soil texture of the study place is appropriate for groundnut production as the crop is grown mostly on light-textured soils ranging from coarse and fine sands to sandy clay loams. The total nitrogen content, available P and organic matter of the experimental site were 0.07%, 7.72 ppm and 0.09%

**Table 2** Some Physicochemical properties of the soil at the experimental field

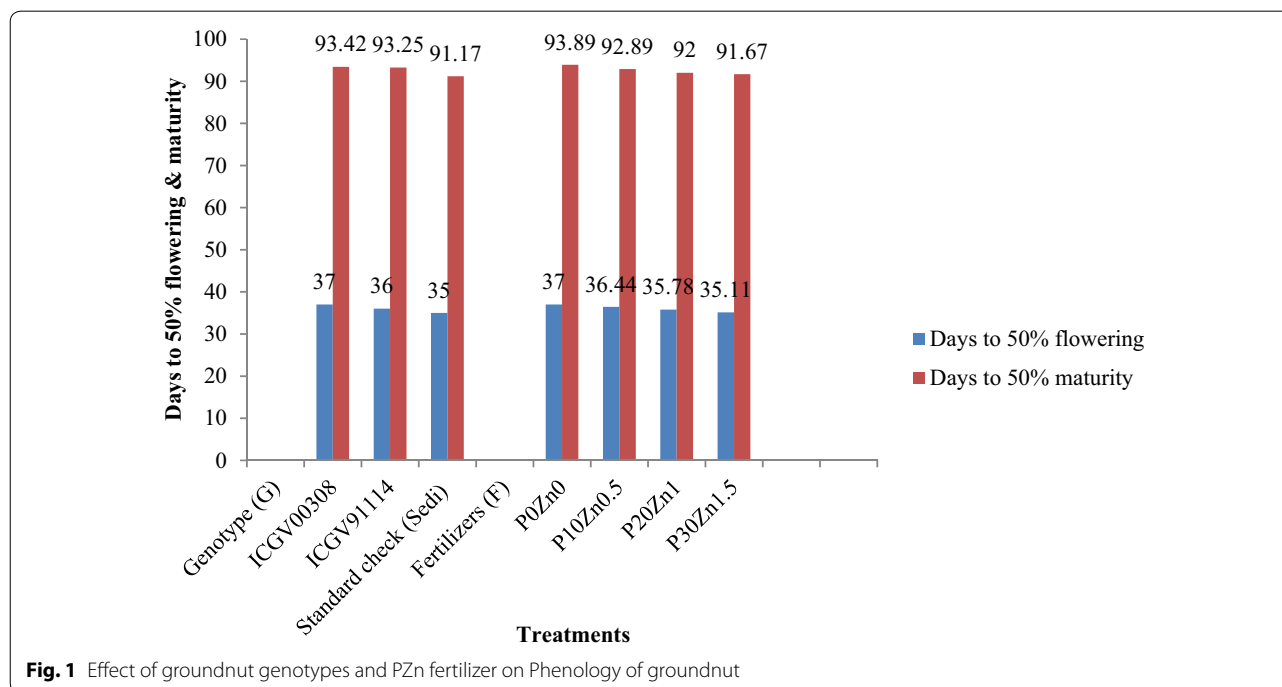
Properties	Values	Remark
Soil physical properties		
Sand (%)	88	
Clay (%)	4	
Silt (%)	8	
Soil texture		Loamy sand
Soil chemical properties		
pH (by 1:2.5 soil water ratio)	7.25	Almost neutral
Total nitrogen (%)	0.07	Very low
Organic carbon (%)	0.09	Very low
Available phosphorus (ppm)	7.72	Very low
Available Zn (ppm)	5.52	Very low
Cation exchange capacity (cmol(+)/kg/ha)	2.7	Very low
Electrical conductivity (ms/cm)	0.045	Very low

Mekelle soil laboratory (2017), as described by Landon (1991)

respectively, which was very low to support the growth of plant. The pH value of the experimental site 7.25 was almost neutral according Tekalign (1991) within the ideal pH range value for groundnut production. Results of cation exchange capacity and electrical conductivity (2.7 cmol (+)/kg/ha) and (0.045 ms/cm) respectively were very low to groundnut cultivation (Landon 1991) and it implied that the soil have low holding exchanging cations but free of salt problem. Results of potassium 238 kg/ha was rated optimum for well growth of the crop (Landon 1991). The level of available Zinc (Zn) in the experimental site was found to be 5.52 ppm which is very low to groundnut production.

### Effects on phenological and growth traits of groundnut

The analysis of variance revealed a significant ( $p < 0.05$ ) genotype and fertilizer main effects for days to 50% flowering. The Sedi variety appeared to flower earlier (35 days) followed by genotype ICGV91114 (36 days). While, the genotype coded as ICGV0308 flowered late (37 days) (Fig. 1). Similar study by Sastry et al. (1985) stated that groundnut genotypes, which flower early during first and the second week of the flowering period produce better yield. The differences observed among the groundnut genotypes in relation to days to flowering can be attributed to the difference in growth characteristics among the genotypes. Verma et al. (2009) reported variable growth patterns in some groundnut genotypes, which could be due to differences in their genetic makeup. The



**Fig. 1** Effect of groundnut genotypes and PZn fertilizer on Phenology of groundnut

main effect of combined phosphorus and foliar spray of zinc also showed significant effect on flowering. That combination may improve utilization of nutrients and water, which reflected on good growth and biological yield.

There was no interaction effect between genotype and fertilizer on between 50% maturity. The main effect of genotypes and fertilizer showed a significant difference for days to 50% maturity. The groundnut genotypes showed a significant difference for days to maturity where the Sedi matures relatively earlier than genotype ICGV91114 and ICGV00308 (Fig. 1). Days to maturity showed a similar pattern with days to flowering with the application of combined fertilizer. The shortest maturity day was recorded from the highest rate.

Analysis of variance indicated that, neither the main effect nor the interaction effect was no significant difference on the leaf width.

ANOVA table revealed that application of combined PZn fertilizer was a significance effect ( $p < 0.05$ ) on leaf length. While the genotype main effect and interaction was no significant effects. The highest length was achieved at the maximum rate of  $P_{30}Zn_{1.5}$  fertilizer (Fig. 2). The average leaf length in the control plots was relatively lower than the treated plots. Increasing the joint application of phosphorus with foliar zinc up to  $P_{30}Zn_{1.5}$  was increasing the leaf length on Sedi variety. In line with current study, Gobarah et al. (2006) reported that increasing P fertilization up to 60 kg  $P_2O_5$ /fad with zinc concentration up to 1 g/L improves leaf length. These effects revealed that foliar nutrition of groundnut

with zinc might increase the efficiency phosphorus utilization and enhancing vegetative growth.

**Effects on yield and yield components**

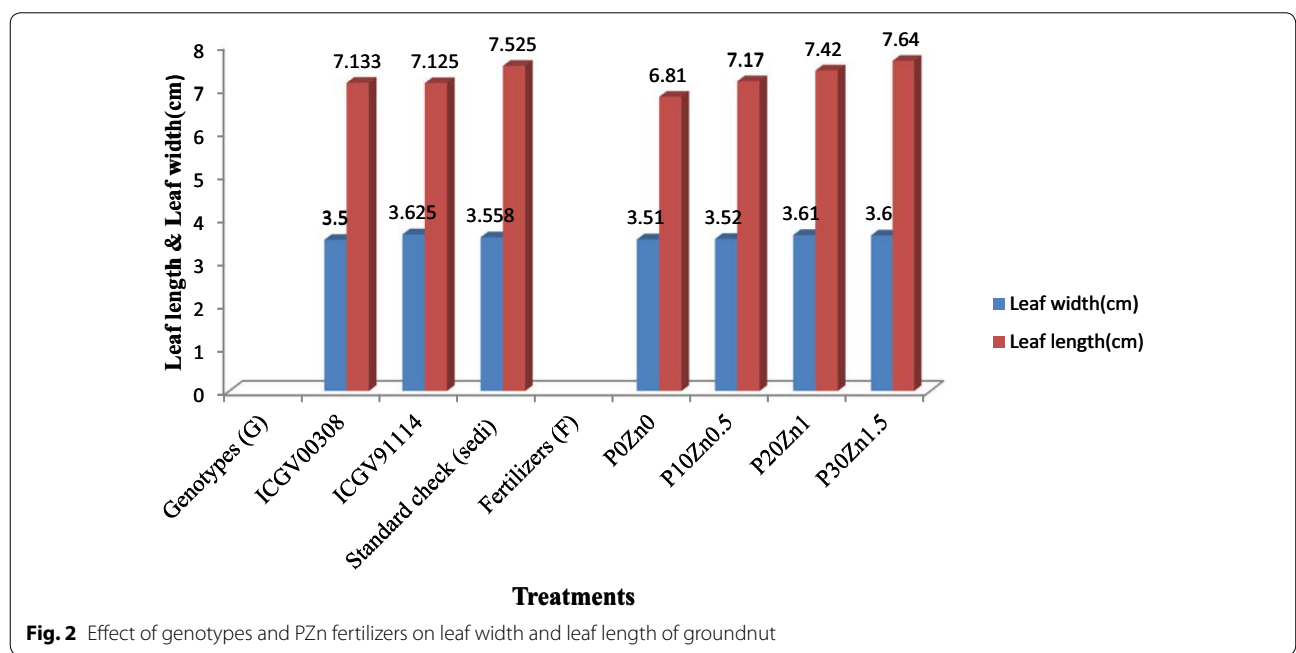
The fertilizer main effect and interaction effects were statistically significant ( $p < 0.01$ ) for number of pods per plant. The highest number of pods per plant (35.4) was recorded from the interaction of genotype ICGV00308 with  $P_{30}Zn_{1.5}$  at par with  $P_{20}Zn_1$  (Table 3). This genotype (ICGV00308) depicted a relatively lower performance in average number of pods per plant (23.13) without fertilizer.

A statistically significant main and interaction effects were showed on pod yield ( $p < 0.01$ ). The highest pod yield was attended from the higher rate of fertilizer with sedi variety. Whereas the lowest pod yield was recorded

**Table 3 The interaction effect of genotypes and PZn fertilizer on pod number/plant**

Genotypes (G)	Combined fertilizers (F)				Mean
	$P_0Zn_0$	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	
ICGV00308	23.13	31.27	33.20	35.40	30.75
ICGV91114	28.07	30.27	31.00	30.73	30
Standard check (sedi)	28.13	29.40	30.50	32.73	30.19
Mean	26.4	30.3	31.6	33	
LSD(0.05) GxF	2.15				
CV (%) GxF	4.2				

P = kg/ha Zn = g/L, LSD (0.05) = least significant difference at 5% level; CV = coefficient of variation



**Fig. 2** Effect of genotypes and PZn fertilizers on leaf width and leaf length of groundnut

from ICGV00308 genotype without fertilizer (control) (Table 4).

Analysis of variance showed that, there were a significant main and interaction effects on number of seeds per pod. The result exhibited that, the highest number of seeds per pod was obtained from Sedi variety with P<sub>30</sub>Zn<sub>1.5</sub> fertilizer (Table 5). While the lowest number of seeds per pod was recorded from the genotype ICGV00308 with P<sub>20</sub>Zn<sub>1</sub> fertilizer. This is may be due to the genetic makeup of the genotype and/or effect of the combined fertilizer.

There were a significant interaction and main effect of groundnut and fertilizer on seed yield of groundnut (p < 0.01). The highest seed yield (2529 kg/ha) and (2516 kg/ha) was obtained from variety Sedi with P<sub>30</sub>Zn<sub>1.5</sub> and P<sub>20</sub>Zn<sub>1</sub> combined fertilizer rate, respectively (Table 6).

While the lowest seed yield (1908 kg/ha) was recorded from ICGV00308 genotype without fertilizer. The highest recorded seed yield increment over this treatment was 33%. Under this treatment significant increase in seed yield may be due to associated improvement in leaf length, leaf width, pod number/plant, pod yield/ha and number of seeds/pods as reported by Jeetarwal (2013). The seed yield has a highly significant and positive correlation with those yield attributes that further support their direct and indirect effect on seed yield in consistency with the report of Bethlehem (Seed yield and quality of groundnut (*Arachis hypogaea* L.), unpublished M.Sc. thesis, Haramaya University, Ethiopia).

Application of combined fertilizers on sedi variety was increase productivity of groundnut per unite area from the current farmers yield of Tanqua-Abergelle (1200 kg/ha) which is very low compare to the yield obtained from the current research finding 2529 kg/ha that proved more than double yield advantage than the farmers practice in the Woreda. Thus, result also exhibited promising increment than the average yield

**Table 4 Interaction effect of genotypes and PZn on pod yield kg/ha of groundnut**

Genotypes (G)	Combined fertilizers (F)				
	P <sub>0</sub> Zn <sub>0</sub>	P <sub>10</sub> Zn <sub>0.5</sub>	P <sub>20</sub> Zn <sub>1</sub>	P <sub>30</sub> Zn <sub>1.5</sub>	Mean
ICGV00308	2904	3072	3198	3302	3119
ICGV91114	3059	3028	3180	3135	3101
Standard check (sedi)	3341	3302	3475	3567	3421
Mean	3101	3134	3284	3335	
LSD (0.05) GxF	237.3				
CV (%) GxF	3.5				

P = kg/ha Zn = g/L, LSD (0.05) = least significant difference at 5% level; CV = coefficient of variation

**Table 5 The interaction effect of genotypes and PZn fertilizer on number of seeds/pod**

Genotypes (G)	Combined fertilizers (F)				
	P <sub>0</sub> Zn <sub>0</sub>	P <sub>10</sub> Zn <sub>0.5</sub>	P <sub>20</sub> Zn <sub>1</sub>	P <sub>30</sub> Zn <sub>1.5</sub>	Mean
ICGV00308	2	1.80	1.67	1.73	1.8
ICGV91114	1.87	1.93	1.87	2.07	1.94
Standard check(Sedi)	2.33	2.67	2.67	2.87	2.64
Mean	2.06	2.13	2.07	2.22	
LSD(0.05) GxF	0.23				
CV (%) GxF	6.3				

P = kg/ha Zn = g/L, LSD (0.05) = least significant difference at 5% level; CV = coefficient of variation

(700 kg/ha) of the region Tigray and 1330 kg/ha of the national productivity (CSA (Central Statistics Agency) 2014). This result is maybe due to the foliar application of zinc with P at the depleted soil supports to this yield.

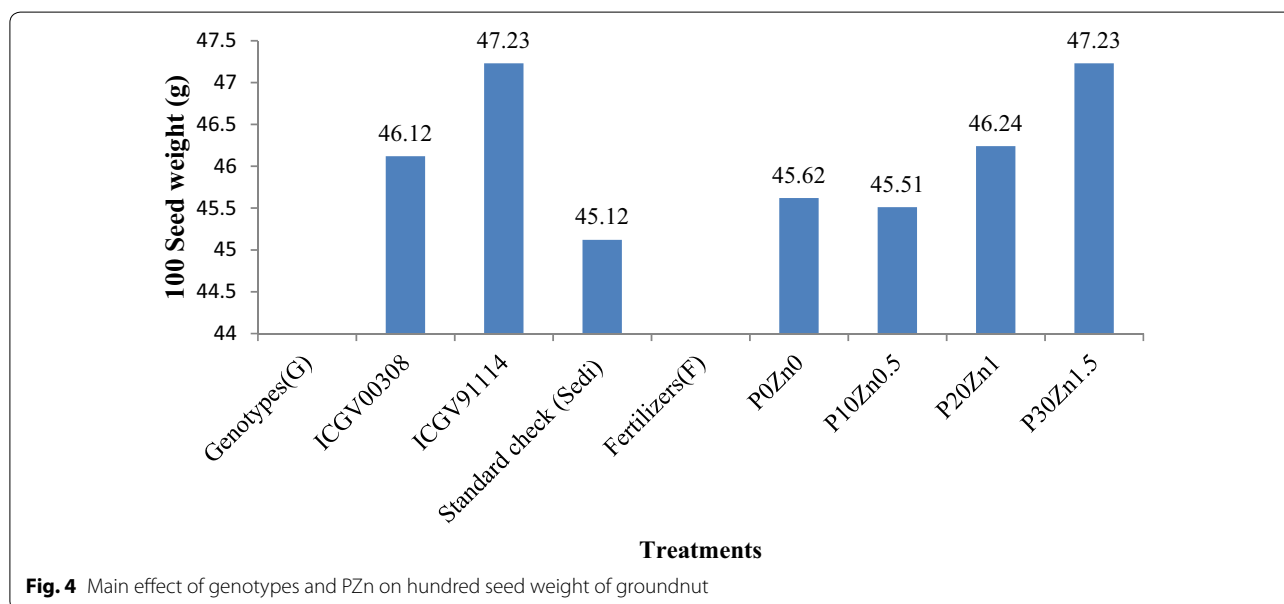
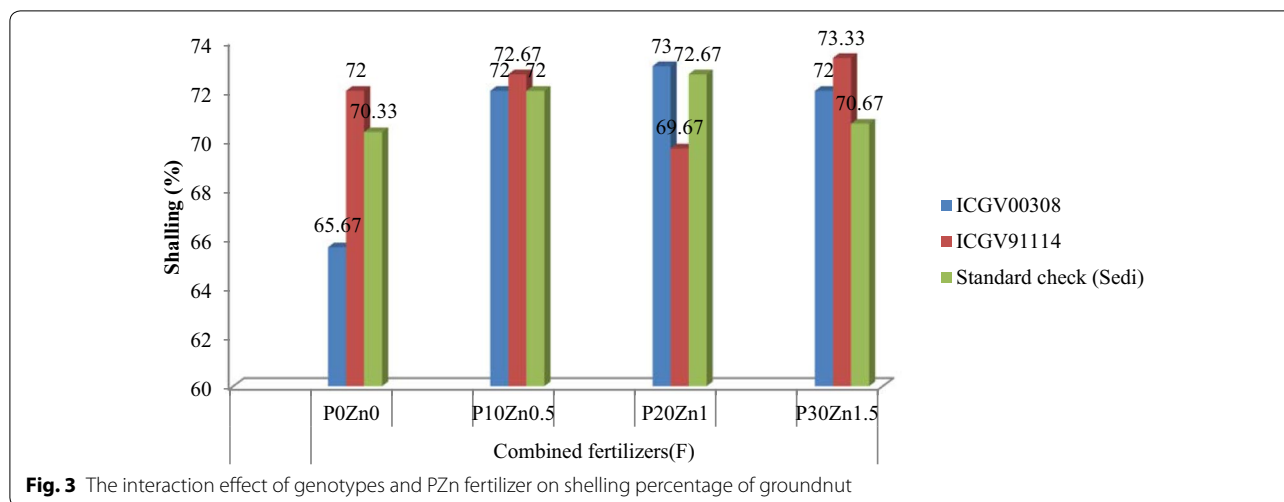
Results showed that main effect of fertilizer rates and interaction effects were statistically significant (p < 0.005) effect on shelling percentage. The highest shelling percentage (73.33) was recorded form genotype ICGV91114 with P<sub>30</sub>Zn<sub>1.5</sub> fertilizer. The lowest shelling percentage was record form genotype ICGV00308 (65.68%) percentage without fertilizer (Fig. 3) and It has a positive correlation with seed yield (r = 0.62) and this was may be due to the application of more fertilizer to the soil and foliar, which enhances these parameters.

Hundred seed weight was significantly (p < 0.05) influenced by the genotype main effect. However, the fertilizer main effect and the interaction component were not significant. The genotype coded as ICGV91114 had relatively higher mean seed weight (47.23 g) than the other genotypes in the finding (Fig. 4). This result is may be due to the genetic differences between the genotypes that is consistent with the idea of Mulatu (2014) who stated that the seed weight characters is more influenced by genetic factors than environment.

**Table 6 Seed yield (kg/ha) as affected by interaction of genotypes and PZn fertilizers**

Genotypes (G)	Combined fertilizers (F)				
	P <sub>0</sub> Zn <sub>0</sub>	P <sub>10</sub> Zn <sub>0.5</sub>	P <sub>20</sub> Zn <sub>1</sub>	P <sub>30</sub> Zn <sub>1.5</sub>	Mean
ICGV00308	1908	2205	2326	2378	2204
ICGV91114	2204	2201	2221	2296	2230
Standard check(sedi)	2351	2384	2516	2529	2445
Mean	2154	2263	2354	2401	
LSD(0.05) GxF	170.8				
CV (%) GxF	4.4				

P = kg/ha Zn = g/L, LSD (0.05) = Least significant difference at 5% level; CV = coefficient of variation



In other hand, hundred seed weight (45.12 g) of the genotype had found in the rage of 35–70 g is under the rage, which fulfills the international market quality of seed grade (Acland 1971).

**Effects on seed nutrition content**

The main effect fertilizer level and the interaction effects were statistically highly significant ( $p < 0.01$ ) for crude protein content. The maximum protein content (37.79%) was recorded from sedi variety at the rate of  $P_{30}Zn_{1.5}$  fertilizer. Nevertheless, the lowest protein content was also recorded from the same variety (Sedi) in the lowest rate of fertilizer (Table 7).

**Table 7** The interaction effect of genotypes and PZn fertilizers on protein content (%)

Genotypes (G)	Combined fertilizers (F)				Mean
	$P_0Zn_0$	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	
ICGV00308	36.78	37.25	37.46	37.46	37.24
ICGV91114	37.13	37.10	36.65	37.03	36.98
Standard check (Sedi)	36.69	35.90	37.36	37.79	36.94
Mean	36.87	36.75	37.16	37.43	
LSD (0.05) GxF	0.69				
CV (%) GxF	1.1				

P = kg/ha Zn = g/L, LSD (0.05) = least significant difference at 5% level; CV = coefficient of variation

The analysis variance showed fat content was exhibited a significant main effect and the interaction effects. The highest percentage of fat content (43.95%) was extracted from ICGV00308 under the highest level of fertilizer ( $P_{30}Zn_{1.5}$ ) (Table 8). While, the lowest fat content was gained from Sedi at untreated condition ( $P_0Zn_0$ ). The significant interaction effects of genotype and fertilizer on crude protein and fat (%) were found in the range of 36.69–37.79 and 41.44–43.95% by the application of  $P_{30}Zn_{1.5}$  fertilizer on Sedi and ICGV00308, respectively. As the rate of fertilizer increases, the percentage of crude protein and fat content tend to increase linearly. Okello et al. (2010) who found 20–50% and 40–50% protein and fat content on groundnut due to fertilizer application, respectively reported similar finding. The current result was in line with Majumdar et al. (2001) also reported that, the percentage of protein increase as a result of an application of phosphorus up to 70 kg  $P_2O_5$ /ha. Gobarah et al. (2006) also noted that P application significantly

increased protein (25.82%) contents on groundnut over control.

**Associations among the groundnut parameters**

A bivariate correlation analysis between the measured traits had positive and negative associations (Table 9). Seed yield had a strong and positive correlation with pod yield ( $r=0.936$ ), leaf length ( $r=0.927$ ), pod number/plant ( $r=0.683$ ), shelling percentage ( $r=0.616$ ) and number seeds/pod ( $r=0.576$ ). Nevertheless, days to 50% flowering and days to 50% maturity were negatively correlated with seed yield, ( $r=-0.833$ ) and ( $r=-0.91$ ), respectively.

**Partial budget analysis**

Partial budget analysis of the interaction effect showed that highest marginal rate of return (380.58%) was obtained from the ICGV00308 genotype at the application of  $P_{10}Zn_{0.5}$  (Table 10). This rate of fertilizer application was economically above the minimum acceptable marginal rate of return (100%) (CIMMYT 1988). This implies that for one birr invested in groundnut production, the producer can get 3.8 ETB.

**Table 8 The interaction of genotypes and PZn fertilizer on fat content (%) of groundnut**

Genotypes	Combined fertilizers				Mean
	$P_0Zn_0$	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	
ICGV00308	43.67	43.76	43.91	43.95	43.81
ICGV91114	42.03	41.45	41.71	43	42.04
Standard check(sedi)	41.78	41.93	43.63	42.9	42.56
Mean	42.49	41.71	43.08	43.28	
LSD (0.05) GxF	0.71				
CV (%) GxF	1				

P = kg/ha Zn = g/L, LSD (0.05) = least significant difference at 5% level; CV = coefficient of variation

**Conclusion and recommendations**

The result of the current field experiment revealed encouraging response of the genotypes to combine P and Zn application, which implied that those factors may be the most limiting features in the loamy sand soil. The highest seed yield (2529 kg/ha) obtained from variety Sedi receiving  $P_{30}Zn_{1.5}$  fertilizer. The result of the current research would provide a useful insight for the smallholder farmers in the study area who often use the

**Table 9 Correlation coefficients between the groundnut parameters as affected by genotypes and PZn combined fertilizers**

Parameters	DF (%)	LW (cm)	LL (cm)	DM (%)	PN/P	PY (kg/ha)	NS/P	S (%)	SY (kg/ha)	HSW (g)	CP (%)	F (%)
DF (%)	1											
LW (cm)	-0.339	1										
LL (cm)	-0.737**	0.474	1									
DM (%)	0.942**	-0.286	-0.824**	1								
PN/P	-0.377	0.235	0.801**	-0.529	1							
PY (kg/ha)	-0.874**	0.175	0.821**	-0.938**	0.513	1						
NS/P	-0.788**	0.114	0.408	-0.732**	-0.101	0.722**	1					
S (%)	-0.33	0.58*	0.674*	-0.373	0.679*	0.305	-0.001	1				
SY (kg/ha)	-0.833**	0.371	0.927**	-0.91**	0.683*	0.936**	0.576*	0.616*	1			
HSW(g)	0.013	0.235	0.004	0.158	0.161	-0.269	-0.34	-0.47*	-0.239	1		
CP (%)	-0.024	0.296	0.445	-0.243	0.509	0.260	-0.126	0.216	0.342	-0.031	1	
F (%)	0.112	0.033	0.186	-0.033	0.252	0.056	-0.186	-0.067	0.049	-0.094	0.542	1

\* and \*\* significant at  $p < 0.05$  and  $p < 0.01$ , respectively and numbers with no \* are non-significant. DF (%) = days to 50% flowering, LW (cm) = leaf width, LL (cm) = leaf length, DM (%) = days to 50% maturity, PN/P = pod Number/plant, PY (kg/ha) = Pod yield, NS/P = Number of seeds/pod, S% = shelling%, SY (kg/ha) = Seed yield, HSW (g) = 100 seed (g) weight (g), CP = crude protein (%), F (%) = fat (%)

**Table 10 Partial budget analysis for groundnut genotypes and fertilizer treatments**

ICGV00308	Fertilizers			
	P <sub>0</sub> Zn <sub>0</sub>	P <sub>10</sub> Zn <sub>0.5</sub>	P <sub>20</sub> Zn <sub>1</sub>	P <sub>30</sub> Zn <sub>1.5</sub>
Net returns (ETB/ha)	42,930	48,222	50,017	50,259.5
Total input cost (ETB/ha)	0	1390.5	2318	3245.5
Domination rank		ND	ND	ND
Marginal benefit (ETB/ha)	0	5292	1795	242.5
Marginal cost (Birr/ha)	0	1390.5	927.5	927.5
MRR (%)		380.58	193.53	26.15
ICGV91114	Fertilizers			
	P <sub>0</sub> Zn <sub>0</sub>	P <sub>10</sub> Zn <sub>0.5</sub>	P <sub>20</sub> Zn <sub>1</sub>	P <sub>30</sub> Zn <sub>1.5</sub>
Net returns (ETB/ha)	49,590	48,132	47,654.5	48,414.5
Total input cost (ETB/ha)	0	1390.5	2318	3245.5
Domination rank		D	D	D
Sedi	Fertilizers			
	P <sub>0</sub> Zn <sub>0</sub>	P <sub>10</sub> Zn <sub>0.5</sub>	P <sub>20</sub> Zn <sub>1</sub>	P <sub>30</sub> Zn <sub>1.5</sub>
Net Returns (Birr/ha)	52,897.5	52,249.5	54,292	53,657
Total input cost (ETB/ha)	0	1390.5	2318	3245.50
Domination rank		D	ND	D
Marginal benefit (ETB/ha)	0		1394.50	
Marginal cost (ETB/ha)	0		2318	
MRR (%)			60.16	

The value written by italic indicated the highest MRR%

D = dominated treatment; ND = non dominated; P = kg/ha; Zn = g/L, ETB = Ethiopian Birr

blanket recommendations of the common fertilizers such as Urea and DAP for all crops including groundnut. The highest percentage of fat and protein were extracted from ICGV00308 and sedi at the highest fertilizer rate (P<sub>30</sub>Zn<sub>1.5</sub>), respectively. From economic point of view, the highest MRR (380.58%) was obtained from the application P<sub>10</sub>Zn<sub>0.5</sub> fertilizer with ICGV00308 genotype. Thus, based on the finding, it can be concluded that genotype ICGV00308 at P<sub>10</sub>Zn<sub>0.5</sub> fertilizer was the most economically attractive option for the farmers in the study area and similar agro ecologies. Further field experiment as well as laboratory analysis should be conducted by incorporating more genotypes over location.

#### Acknowledgements

My first and foremost thanks go to my advisor's Dr. Dereje Assefa and Dr. Yemane Tsehaye for their guidance and constructive comments starting from the idea of proposal writing up to the final stage with sharing me their accumulated professional experience with kind approach. I am highly thankful to Tigray Agricultural Research Institute (TARI) and NORHED-Sweet Potato Project for financial support.

#### Authors' contributions

HM designed the study and collect data, analyzed the data and drafted the manuscript, DA contributed to review the first draft of the manuscript and YTS also contributed to review the second draft of the manuscript. All authors read and approved the final manuscript.

#### Funding

Tigray Agricultural Research Institute.

#### Availability of data and materials

Not applicable.

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The author declares no competing interests.

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Received: 1 May 2020 Accepted: 17 October 2020

Published online: 06 November 2020

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