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:*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 (2,529 kg/ha) and protein content (37.79%) were obtained in response to the application of $P_{30}Zn_{1.5}$ 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 $P_{30}Zn_{1.5}$ fertilizer. From the interaction of sedi with $P_{30}Zn_{1.5}$ fertilizer was recorded highest protein content. Based on economic analysis the highest MRR (380.58%) was obtained from ICGV00308 genotype at $P_{10}Zn_{0.5}$ 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 $P_{10}Zn_{0.5}$ fertilizer was optimum for groundnut production in the study area and similar agro-ecologies.*

1: 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 (Basavaraj *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.

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 1,151,800.37 quintals, respectively (CSA, 2016).

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. 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 %), Mirvat *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.

2: Materials And Methods

The study area (Sheka-Tekli) is considered as one of the most important place in Tanqua -Abergelle district, Tigray Region (Northern Ethiopia) for the production of groundnut. The study area lies between a latitude of 13^0 33' 08" N, longitudes 39^0 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 varies from 350mm – 700 mm with minimum and maximum temperature of 24^0c and 41^0c, 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 (Walkely and Black, 1934) by volumetric, cation exchange capacity by ammonium acetate method (FAO, 2008) were analyzed in Mekelle soil laboratory and available Zn by atomic absorption spectrophotometer at ezana analytical laboratory are given in (Table 2.1).The groundnut genotypes: ICGV00308, ICGV91114 and Sedi (standard check) were used for planting materials

Table 2. 1: Description of the genotypes used in the study

Genotypes	Status	Source	Color
ICGV00308 (G_1)	Advanced line	ICRISAT-Mali	Light white
ICGV91114 (G_1)	Advanced line	ICRISAT-Mali	Light white
Standard check (Sedi)	Released variety	Melka-Werer ARC	Light red

Fertilizer treatment phosphorus as triple super phosphate (TSP) and zinc sulphate ($ZnSo_4$ $7H_2O$) 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($P_{10}Zn_{0.5}$), 20kg P/ha + 1g 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 X 2 m), having 45 cm distance between rows and 20 cm between plants and 15kg 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 & 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).

3: Results

3.1 Selected Physicochemical Properties of the Study Site

The soil texture of the experimental area was appeared to be loamy sand (Table 3.1). 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% 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 (2.7cmol (+)/kg/ha) and (0.045ms/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 238kg/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.

Table 3.1: 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 London (1991)

3.2 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) (Figure 3.1). 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 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.

Figure 3.1: Effect of groundnut genotypes and PZn fertilizer on Phenology of groundnut

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 (Figure 3.1). 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, nether the main effect nor the interaction effect were no significant difference on the leaf width.

Figure 3.2: Effect of genotypes and PZn fertilizers on leaf width and leaf length of groundnut

ANOVA table revealed that application of combined PZn fertilizer wes 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 (Figure 3.2). 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, Mirvat (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.

3.3 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 3.2). This genotype (ICGV00308) depicted a relatively lower performance in average number of pods per plant (23.13) without fertilizer.

Table 3.2: The interaction effect of genotypes and PZn fertilizer on pod number/plant

Genotypes(G)	Combined fertilizers(F)				
	P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	Mean
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	2.153				
CV (%) GxF	4.2				

Where P=kg/ha Zn=g/L, LSD (0.05) =Least Significant Difference at 5% level; CV= Coefficient of variation.

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 from ICGV00308 genotype without fertilizer (control) (Table 3.3).

Table 3.3: Interaction effect of genotypes and PZn on pod yield kg/ha of groundnut

Genotypes(G)	Combined fertilizers(F)				
	P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	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				

Where P=kg/ha Zn=g/L, LSD (0.05) =Least Significant Difference at 5% level; CV= Coefficient of variation.

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 $P_{30}Zn_{1.5}$ fertilizer (Table 3.4). While the lowest number of seeds per pod was recorded from the genotype ICGV00308 with $P_{20}Zn_1$ fertilizer. This is may be due to the genetic makeup of the genotype and/or effect of the combined fertilizer.

Table 3.4: The interaction effect of genotypes and PZn fertilizer on number of seeds/pod

	Genotypes(G)	Combined fertilizers (F)				
		P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	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					

Where P=kg/ha Zn=g/L, LSD (0.05) =Least Significant Difference at 5% level; CV= Coefficient of variation.

There were a significant interaction and main effect of groundnut and fertilizer on seed yield of groundnut ($p < 0.01$). The highest seed yield (2,529 kg/ha) and (2,516 kg/ha) was obtained from variety Sedi with $P_{30}Zn_{1.5}$ and $P_{20}Zn_1$ combined fertilizer rate, respectively (Table 3.5).

Table 3.5: Seed yield (kg/ha) as affected by interaction of genotypes and PZn fertilizers

	Genotypes(G)	Combined fertilizers(F)				
		P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$	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					

Where P=kg/ha Zn=g/L, LSD (0.05) =Least Significant Difference at 5% level; CV= Coefficient of variation.

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 /pod 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 (2011).

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 2,529 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 (700 kg/ha) of the region Tigray and 1,330 kg/ha of the national productivity (CSA, 2016).

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 $P_{30}Zn_{1.5}$ fertilizer. The lowest shelling percentage was record form genotype ICGV00308 (65.68%) percentage without fertilizer (Figure 3.3) 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.

Figure 3.3: The interaction effect of genotypes and PZn fertilizer on shelling percentage of groundnut

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 (Figure 3.4). 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. In other hand, hundred seed weight (45.12g) 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).

Figure 3.4: Main effect of genotypes and PZn on hundred seed weight of groundnut

3.4 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 3. 6).

Table 3.6: The interaction effect of genotypes and PZn fertilizers on protein content (%)

Genotypes(G)	**Combined fertilizers(F)**				
	P_0Zn_0	**$P_{10}Zn_{0.5}$**	**$P_{20}Zn_1$**	**$P_{30}Zn_{1.5}$**	**Mean**
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	0.6938				
CV (%) GxF	1.1				

Where 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 3.7). 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.

Table 3.7: The interaction of genotypes and PZn fertilizer on fat content (%) of groundnut

Genotypes	**Combined fertilizers**				
	P_0Zn_0	**$P_{10}Zn_{0.5}$**	**$P_{20}Zn_1$**	**$P_{30}Zn_{1.5}$**	**Mean**
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	0.712				
CV (%) GxF	1				

Where P=kg/ha Zn=g/L, LSD (0.05) =Least Significant Difference at 5% level; CV= Coefficient of variation.

3.5 Associations among the Groundnut Parameters

A bivariate correlation analysis between the measured traits had positive and negative associations (Table 3.8). Seed yield had a strong and positive correlation with pod yield (r=0.936), leaf length (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.

Table 3.8: 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

Where; *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)=100seed (g) weight (g),CP= Crude protein (%), F (%)=Fat (%)

3.6 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 3.9). 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 3.9: Partial budget analysis for groundnut genotypes and fertilizer treatments

ICGV00308	Fertilizers			
	P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$
Net Returns (ETB/ha)	42930	48222	50017	50259.5
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 (%)	**-**	**380.583**	**193.531**	26.1456
ICGV91114	**Fertilizers**			
	P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$
Net Returns (ETB/ha)	49590	48132	47654.5	48414.5
Total input cost (ETB/ha)	0	1390.5	2318	3245.5
Domination rank		D	D	D
Sedi	**Fertilizers**			
	P_0Zn_0	$P_{10}Zn_{0.5}$	$P_{20}Zn_1$	$P_{30}Zn_{1.5}$
Net Returns (Birr/ha	52897.5	52249.5	54292	53657
Total input cost (ETB/ha)	0	1390.5	2318	3245.5
Domination rank		D	ND	D
Marginal benefit (ETB/ha)	0		1394.5	
Marginal cost (ETB/ha)	0		2318	
MRR (%)			60.16	

Where: D=dominated treatment; ND=non dominated; P=kg/ha; Zn=g/L

4: Discussion

4.1 physical and chemical property of the soil

The soil analysis revealed that the soil of the testing site was loamy sand with available phosphorus of 7.72 ppm, which is very low for most crops including groundnut (Sahlemedhin, 2001). At the experimental site, it was phosphorus that was the major restraining factor for the groundnut production and thus, its application was important to enhance optimum yield. Phosphorus deficiency constitutes a severe limitation to crop production in weathered tropical soils containing high Fe and Al oxides that quickly fix added P. The pH of the soil at the trial site was 7.25, considered favorable for groundnuts (Murata, 2003). According Nkot et al. (2011) stated reduced groundnut nodulation and fixation of nitrogen in acid soils pH of 3.6 -6.9.

Very low content (0.07%) of total nitrogen in the soil was observed at the experimental site, This was may be due the past frequent farming with little and/or no application of inorganic as well as organic fertilizers. The level of organic matter (0.09%) is also very low to meet the crop growth requirement, which impels to low water holding capacity. Nitrogen is not mandatory in large amounts to groundnut since it fixes atmospheric nitrogen by nature. Tubbs et al. (2012) reported that nitrogen availability in the soil is essential for vegetative growth as such, however, addition of nitrogen fertilizers at low rate as a starter dose to groundnut crop is important mainly where content of the nitrogen in the soil is low.

According to Moazed et al. (2010) limited soluble Phosphorus in soils is reduce crop production and productivity. Nevertheless, zinc is also a very important nutrient for building metabolites due to activating effect of several enzymes involved in biosynthesis of growth substances, which produce more plant cells and dray mater accumulation (Darwish e t al., 2002). However, the amount of zinc found in the experimental area as the soil laboratory result displayed (5.52ppm) was below enough to for groundnut production.

Furthermore, the soil analysis results showed that potassium 238 kg/ha were acceptable for the crop overall growth (Landon, 1991). Results also revealed that cation exchange capacity and electrical conductivity (2.7cmol (+)/kg/ha) and (0.045ms/cm) respectively are very low to groundnut cultivation (Landon, 1991) and it implied that the soil have low holding exchanging cations but free of salt problem.

4.2 Phenological Parameters

Flowering is a very important physiological process in plant developmental phase and has a profound effect on the economical final yield of the crop. The statistical analysis revealed a clear effect of the genotype as well as the application of a combination of phosphorus with foliar application of zinc fertilizer on days to 50% flowering and days to 50% maturity on groundnut. In the main effect groundnut genotypes and the combined fertilizers showed significant effect, where the standard check variety Sedi flowered earlier at the highest level of combined fertilizer (30 kg P/ha + 1.5 g Zn/L).

In the study genotypes flowered earlier produce greater yields. 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.

Furthermore, the variation occurred due the main effect of combined fertilizer also may be resulted from the zinc applied as foliar application that enhances photosynthesis at early growth of the plants that improves nitrogen fixation and phosphorus utilization which promotes rapid growth stage. In addition to that, combination of Phosphorus fertilizer and foliar spray with zinc may improve utilization of nutrients and water, which was revealed and reflected in a good growth and biological yield. This result is in full agreement with Mirvat et al. (2006) who showed phosphorus application from 0 - 60 kg/fad could possibly shortens maturity of groundnut.

4.3 Growth Parameters of Groundnut

Analysis of the result indicated that, growth parameters, leaf width and leaf length of groundnut did not show a significant variation for the interaction of combined fertilizers and genotype. However, the main effect of the combine phosphorus with foliar application of zinc on leaf length was significant. The difference in leaf length may be the large amount of phosphorus with zinc application, as phosphorus plays crucial roles in enhancing development of extensive root system which resulting into increase nutrient uptake. Besides the foliar spraying with zinc may encourage the vegetative growth and by thereby increased dry mater accumulation *via* the plant capacity for building metabolites. Increasing the joint application of phosphorus with foliar zinc up to 30 kg P/ha + 1.5 g Zn/L are increasing the leaf length on Sedi variety. In line with current study, Mirvat (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.

Furthermore, the significantly enhanced leaf length of the genotype might be due to increasing of phosphorus level with foliar application of zinc plays an important role to in conservation and transfer of energy in metabolic reaction of living cells and root development. The current finding is in agreement with the report of Jeetarwal (2013) that application of phosphorus enhance nutrient availability and uptake of N, P and Zn that results vigorous growth parameters.

4. 4 Yield and Yield Components

The application of different fertilizer levels had significantly affected pod number/plant, pod yield/ha, number of seeds/pod, seed yield/ha and shelling percentage. This result was concurrent to the study carried out by Mirvat (2006) who reported a significant influence of combined application of phosphorus with foliar zinc on the yield component traits that the combined nutrient application may enhance the nutrients and water utilization that enhances yield component traits.

The interaction and main effect of combined fertilizers and genotypes had on influence on the yield and yield traits. Mainly the interaction of combined phosphorus with foliar zinc and genotype had influence on pod number/plant, pod yield/ha, number of seeds/pod, seed yield /ha and shelling percentage.

The increasing trend of the combined fertilizer level from 0-30 kg P/ha + 1.5 g Zn/L with different genotypes showed an increment on yield and yield parameters might be due to the effect of combination of phosphorus with foliar zinc fertilizer level on number and weight of nodules and nitrogen activity which in turn affects positively the yield component traits. Furthermore, the increment in yield may also be resulted due to the phosphorus fertilizer attributed to the activation of metabolic process as stated by Marschner (1986). Similarly, the foliar spraying with zinc might lead to increase in number of pods and seeds/plant, weight of pods and seeds/plant. Since zinc fertilizer often attributed to the vital role of activating enzymes in biological process that may, help to increase yield characters.

In general, the higher seed yield depicted by the variety Sedi under the combined application of phosphorus and foliar zinc might be characteristics of higher yielding potential of the variety as well as efficient utilization of growth resources. Similar to this result, Ofori (1996) also stated that variety of Bambara groundnut with the spreading growth habit produce flower throughout growing season and gives high yields.

Highly significant increase seed yield was obtained from the application of 30 kg P/ha+1.5 g Zn/L on Sedi variety (2,529 kg/ha). 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 /pod 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 the crop.

Application of combined fertilizers on the standard check variety sedi could 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 2,529 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 (700 kg/ha) of the region Tigray and 1,330 kg/ha of the national productivity (CSA, 2016).

In the result also observed that the phonological traits (days to 50% flowering and maturity) had a strong negative correlation with most of the yield attributes (except hundred seed weight) such as pod number/plant, pod yield/ha number of seeds/pod and seed yield that was consistency with the report of Bethlehem (2011).

This indicated that when the crop matures earlier particularly under stress condition and when the growing season is too short and when terminal drought is frequent, early maturing genotypes may escape the stress and yield better than the long maturing genotypes. Moreover, the late maturing genotypes may be affected by weather fluctuation such as shortage of moisture (rainfall) and high temperature that was apparent in the latter growth stage of the crop. This was in agreement with the findings of Samalulu et al (2014) who reported the effect and the influence of micro climatic conditions and soil has on the growth of difference groundnut genotypes. As the variety Sedi matures earlier than others and provided relatively higher yield as compared with the other testing new genotypes, under a well-managed condition (better nutrient application), the local genotype would still be suitable to the area where terminal drought is the norm.

Hundred seed weight is one of the yield-contributing traits in groundnut. In this study, the combined application of phosphorus with foliar application of zinc on groundnut has not revealed any significant effect on hundred seed weight. However, hundred seed weight of groundnut was significantly influenced by genotypes main effect, where the higher seed weight was recorded by ICGV91114 (47.23 g) than variety Sedi (45.12 g). 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.

In other hand, hundred seed weight (45.12g) 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).

Shelling (%) is an indication of pod filling efficiency so the highest percentage value had a direct effective on pod filling. In this finding the interaction of combined fertilizer and genotype significantly affected shelling percentage (%) of groundnut in a linear fashion with increasing phosphorus and foliar zinc application. The variety Sedi had the highest record for this trait. This might be due to fertilizer rates hasten the pod formation then efficient assimilates rather move to the seed when the moisture is available especially at dryland area.

Furthermore, 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. This was in agreement with mulatu (2014) who reported variation in variety and efficient partitioning of assimilates in to seed than pods.

4.5 Crude Protein and Fat (%)

The application of combined fertilizer had an interaction effect with the genotypes for crude protein and fat. The crude protein and fat (%) ranged 36.69 - 37.79 and 41.44 - 43.95% by combined application of 30 kg of P/ha + 1.5 g Zn/L fertilizer on Sedi and ICGV00308, respectively. Okello et al. (2010) who found 20-50% and 40-50% protein and fat content on groundnut due to fertilizer application, respectively also reported similar finding.

The increment in protein and fat % may attributed to the contribution of the genotype difference and combined application of phosphorus with foliar zinc as it was revealed from the significant interaction effect. 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.

The interaction of the combined fertilizer level and genotypes was strongly and positively affected the fat percentage, which recorded highest percentage from the treatment, which had received the highest combined fertilizer levels.

As the result displayed the highest fat percentage is extracted from the ICVG00308 genotype that showed an increasing trend (linearly) from control (zero application) to the maximum level of combined fertilizer. This could possibly due the combined effect of phosphorus with zinc that have on the metabolic processes and growth that in turn reflected positively on the biochemical content of the groundnut seed. Similar to the current study, Mirvat et al., (2006) and Kausale et al. (2009) also reported maximum oil content and fat in seeds of groundnut with the application of those fertilizers. The crude fat content 43.95% had found from the highest fertilizer combination and the result is in line with finding of Evans et al. (2015) reported that fat content of groundnut in the range 33.6-54.95%.

4.6 Partial Budget Analysis

The dominance as well as economic analysis on marginal rate of return (MRR) showed that the combination of $P_{10}Zn_{0.5}$ fertilizer on ICGV00308 genotypes had better gain over the other treatments (380.58%) (Table 4. 12). Generally, the combined application of $P_{10}Zn_{0.5}$ fertilizers on the genotype coded as ICGV00308 had the highest percentage of MRR that clearly confirmed that, the additional capital invested may economically feasible than the unfertilized treatment while the other genotypes with the fertilizer application was non-significant.

In addition, this rate of fertilizer application was economically acceptable than the other dominant treatments although the marginal rate of return obtained from all dominant treatment was above the minimum acceptable marginal rate of return. This implies that for one birr invested in groundnut production, the producer can get 3.8 ETB. The most important key finding of this result would be low input cost and relatively good seed yield of the genotype. While the lowest marginal rate of return (26%) from the highest combined fertilizer level on the genotype ICGV00308 due to the cost of fertilizer (Table 12).

5: 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 the most limiting features in the loamy sand soil. The highest seed yield (2,529 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 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 ($P_{30}Zn_{1.5}$), respectively. From economic point of view, the highest MRR (380.58%) was obtains from the application $P_{10}Zn_{0.5}$ fertilizer with ICGV00308genotype. Thus, based on the finding, it can be concluded that genotype ICGV00308 at $P_{10}Zn_{0.5}$ 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 conduct by incorporating more genotypes over location.

Declaration

Ethics approval and consent to participate: Both are agreed

Consent for publication: Both area decide to publication

Availability of data and materials: Are from direct from field and research center

Competing Interest: The author declares no competing interest

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Author 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 DA also contributed to review the second draft of the manuscript. Authors are check and agreed the final manuscript

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Figures

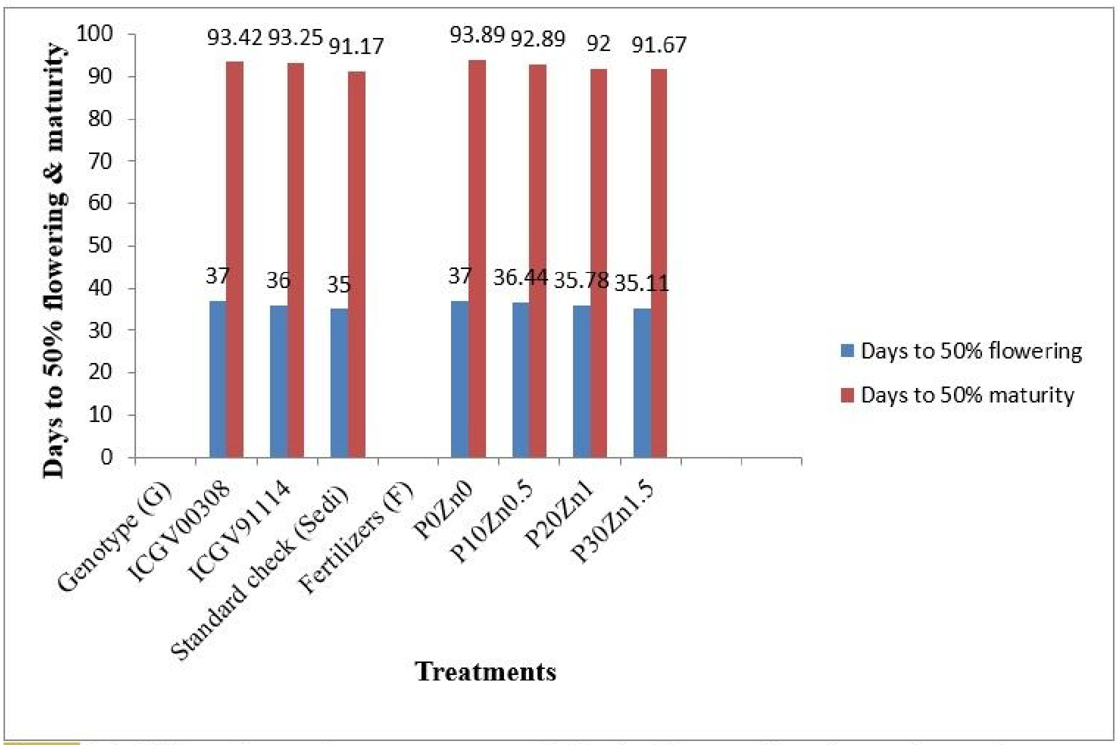

Figure 3.1: Effect of groundnut genotypes and PZn fertilizer on Phenology of groundnut

Figure 1

Effect of groundnut genotypes and PZn fertilizer on Phenology of groundnut

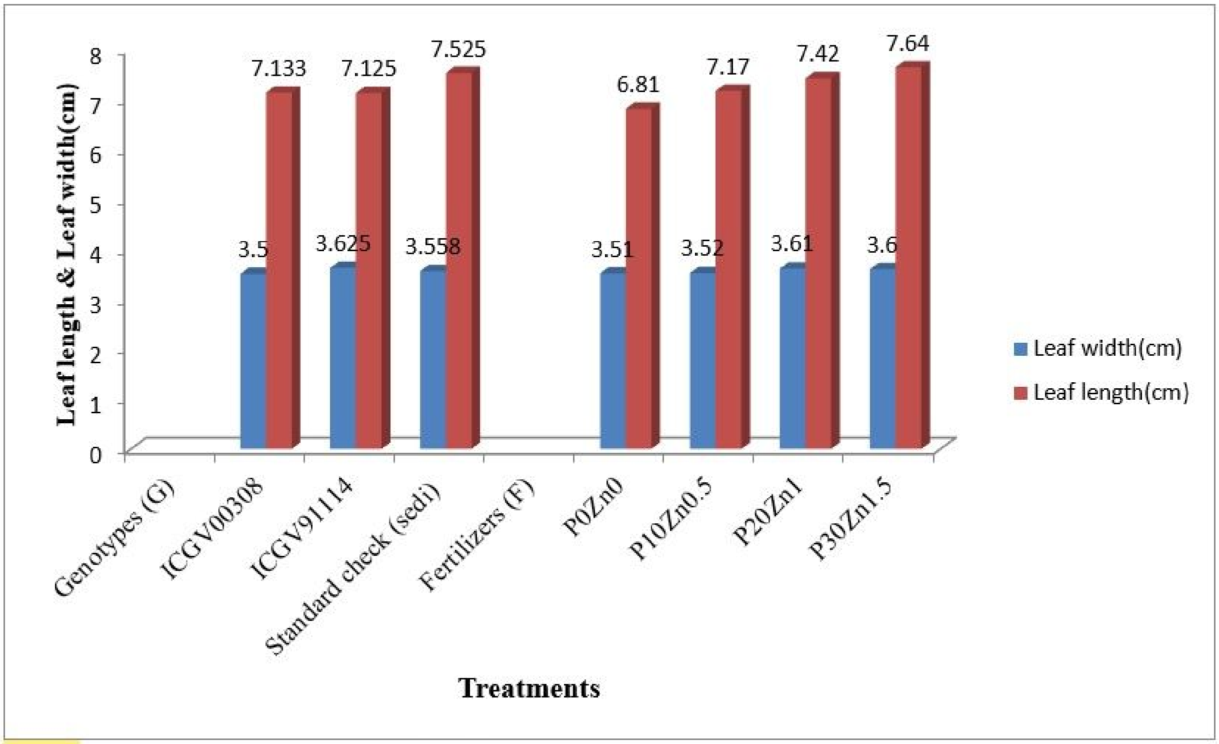

Figure 3.2: Effect of genotypes and PZn fertilizers on leaf width and leaf length of groundnut

Figure 2

Effect of genotypes and PZn fertilizers on leaf width and leaf length of groundnut

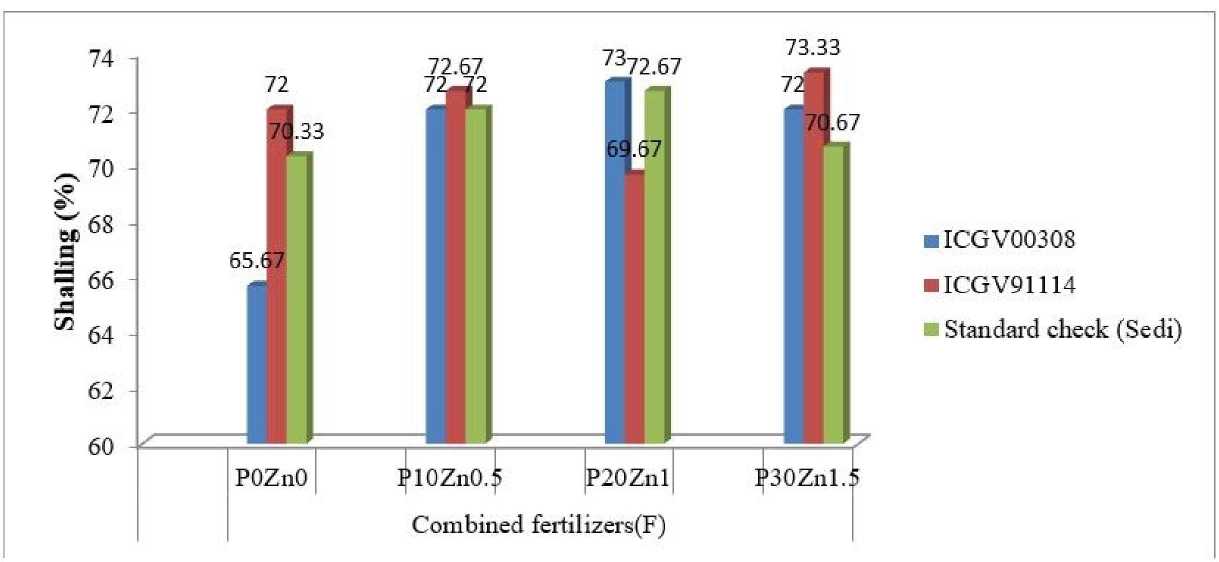

Figure 3.3: The interaction effect of genotypes and PZn fertilizer on shelling percentage of groundnut

Figure 3

The interaction effect of genotypes and PZn fertilizer on shelling percentage of groundnut

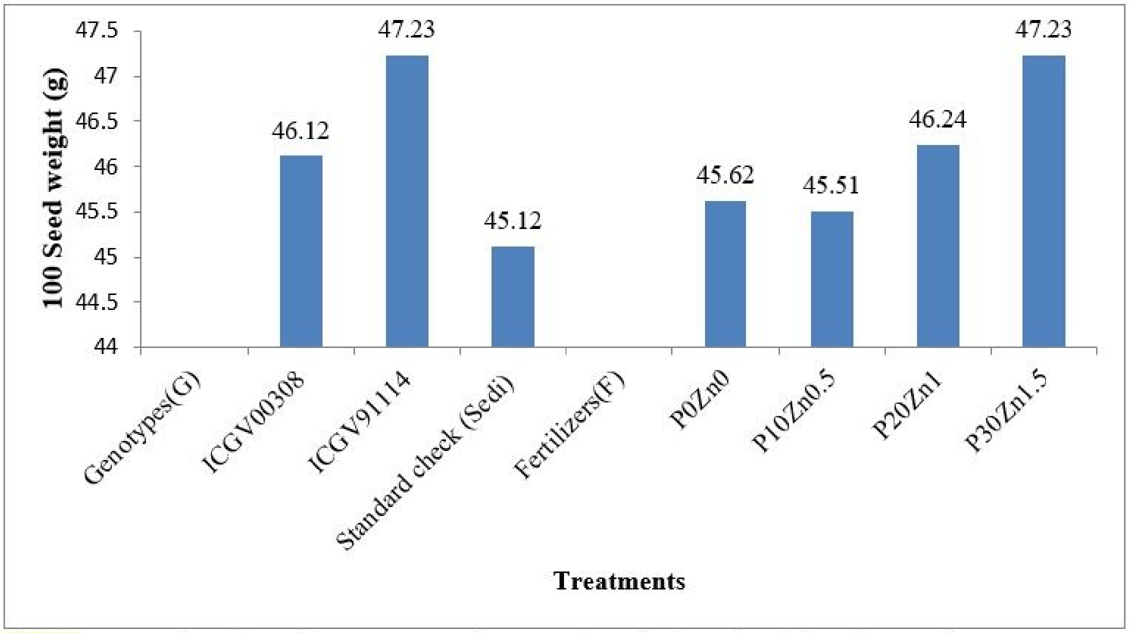

Figure 3.4: Main effect of genotypes and PZn on hundred seed weight of groundnut

Figure 4

Main effect of genotypes and PZn on hundred seed weight of groundnut