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Wheat Agromorphology Characters as Affected by Fertilizers in Southern Humid Forest of Côte d'Ivoire: Exploring cations effect on wheat growth in an inherent marginal ecology

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Abstract: An alternative of crop adaptation to climate change may be achieved by extension in new ecosystems. In this circumstance, stimulation of growth hormones should be advocated. Therefore, a fertilizer trial of wheat (*Triticum durum*desf) was set in rainfed condition of the south of Côte d'Ivoire. The experiment design was a randomized complete bloc design with three replications including seven pots as treatments. A rate of 200 $kgha^{-1}$ as NPK (15, 22, 22) basal fertilizer was applied. The rates of 50 $kgha^{-1}$ as magnesium sulfite and 10 $kgha^{-1}$ of zinc sulfite were used for the treatments NPKMg, NPKZn, NPKMgZn, Mg and Zn. A rate of 35 $kgha^{-1}$ was also applied as urea at tillering and bosting stages respectively. The results showed highest grain yield in a range of 3.47 tha^{-1} for the treatment NPK. A negative impact of cations on photoperiod and a depressing effect of low rate of K was deemed responsible of low tillering and the limited plant high. Presuming effects of Zn and Mg were only limited to the reproductive stage without affecting the grain yield because of low development of the rhizosphere. There is chance to increase the grain yield of 3.47 tha^{-1} recorded by for the treatment NPK when increasing the rate of K for improving wheat production in the forest zone of south Côte d'Ivoire.

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1) INTRODUCTION

Wheat (*Triticuma estivium L.*) is a staple food as the most cultivated cereal worldwide and following rice in adoption level as food, when supplying 15% of world energy requirement (Bajji, 1999). Africa is importing 31,5 million of tone annually for about 60% of gross demand (CIMMYT, 2015).

In fact, wheat cultivation in Africa was traditionally limited to the North (FAO, 2010) because of the dryer climate requirement, particularly with high temperature in day time alternating with cold night times (*Agriculture et Agro-alimentaire Canada*, 2000) : wheat cropping requires a temperature between 10˚C and 30˚C, and annual rainfall ranging between 600 and 1500 mm, almost lower than the records in tropical Africa (Zouaoui*et al*, 2007 ; Celement, 1981). Highest temperature occurrence in there can negatively impact wheat pollinization and fecundation (Mackill et *al*., 1982 ; Zhang and Mackill, 1982). However, the increasing temporal and spatial perturbation events of Intertropical Front progress are observed, hence modifying climate characteristics (Windmeijer, 1993).

Well, in the current context of Global Environment Changes (GEC) characterized by rainfall reduction coupled with modification of extreme temperatures (Bruijn and van Dijk, 2006), the challenge is the adaptation of living being to the new characteristics of their environment, especially for crop (Dugue, 2012 ; Amssa *et al*., 2000).

In this line, reinforcement of rainfed rice tolerance to mid-season drought was explored by Koné*et al.* (2008) emphasizing the implication of mineral nutrition like the concept of haying-off under nitrogen effect in limited soil moisture condition and calcium acting as stress signal transducteur (Karabaghli *et al*., 1997; Khelil *et al*., 2013). Even judicious as fertilization practice for environmental stress management in agriculture which can influence the quality and the food value of the grain (Desheva, 2016), it can be supported by relocation (extension) of cropping areas in relation with new climatic conditions and genotype diversity as currently observed for wheat (Lacock and Botha, 2000).

Indeed, West Africa region is the most affected by climate changes worldwide and characterized by a rainfall reduction with abnormal variability of air temperature (Munang *et al*., 2014), there may have chance to discover new agro-ecologies for some wheat cultivar. Therefore, the southern forest zone of Cote d'Ivoire becoming less and less humid (Whitmore, 1998) with the lowest air temperature of the country should be explored for this purpose. However, the widespread soil mineral deficiencies in nitrogen (N), phosphorus (P) and potassium (K) in this region (Godefroy *et al*., 1970; Boyer, 1982) that need to be replenished should be coupled with the reinforcement of plant integrity by cations as magnesium (Mg) and zinc (Zn) potentially acting in plant metabolisms, the tolerance to stress and gene expressions (Scott and Robson, 1990; Barton, Nakanishi and Meth-Cohn O. 1999; Andreini *et al*., 2006).

Therefore, the current study is volunteer to explore chances for wheat cropping in the region of Abidjan, in south of Côte d'Ivoire. The aim was, i) to specify morphological and agronomic characteristics of wheat in this agro-ecology, ii) identify site specific fertilizer practice for wheat and, iii) to lay the groundwork of wheat cultivation in Côte d'Ivoire. Overall, this study should underline the opportunities to for wheat cropping in the forest zone of West Africa.

2) MATERIAL AND METHODS

2-1) Site and design of the study

The study was laid in the botanic center of Felix Houphouet-Boigny University (05°20'50.2''N; 03°59'10.6''W; 52 m asl) in the distric of Cocody (Abidjan). It is located in the South of Côte d'Ivoire. The air temperature is ranging between 28˚2C – 23˚9C with 2008.8 mm of annual rainfall amount characterized by a bimodal rainfall pattern.

In December 2013, May 2014 and June 2015, five kilograms (5 kg) of soil were taken using hue and transferred in twenty one (21) plastic pots of 4 liters that were characterized by 277.75 cm^2, 18 cm and 20 cm in dimension of top area surface, depth and inner diameter respectively. Soil sampling was done in 0 – 20 cm depth under forest vegetations. The pots were arranged in three (3) replications of seven pots. A rate of 200 $kgha^{-1}$ of NPK-Fertilizer (15 %N – 22 %P_2O_5 – 22 %K_2O) was applied incorporating into soil as basal before sowing. Furthermore, 50 $kgha^{-1}$ of magnesium sulfite ($MgSO_4.H_2O$; 27% Mg) and 10 kg ha^{-1} of zinc sulfite ($ZnSO_4.H_2O$; 23% Zn) were considered for the composition of seven treatments as NPK, NPKMg, NPKZn and NPKMgZn beside the treatments of Mg, Zn and the control (blank). Two grains of rainfed wheat cultivar (unknown) from Italy were sown per pot. A randomized couplet block design was laid and 35 $kgha^{-1}$ of urea ($CO(NH_2)_2$; 46% N) was applied each time at tillering and panicle initiation stages. Irrigation water supplying was 20mm (555 cc) in three days period without rainfall. Weeding was done manually when necessary.

2-2) Plant data collection

Seven (7) and fifteen (15) days after sowing (DAS), the seed germination rate was determined by treatment. The leave number per stand and treatment was counted on 10 and 15 DAS. Plant high and circumference were also measured at different physiological stages for the determination of plant growth rate and vigor index (VI). The dates of tillering, bosting, panicle initiation, flowering and maturity were recorded respectively. At maturity stage, plant high was also measured per treatment. The harvest was done per pot before sundry and threatened for grain and straw separation in the course of yields determination. The grain yield (GY) was determined as bellow referring to 14% of grain moisture content:

$$GY(t/ha) = (\text{Grain weight} / 2,78) \times (10^4 / 10^6) \times ((100 - \text{moisture}) / 86) \quad [1]$$

The straw yield (SY) was also determined according to equation [2]:

$$SY(t/ha) = (\text{Straw weight}/10^6)) / (0.028/10^4) \quad [2]$$

Total dry matter (TDM) was also calculated on basis of the grain and straw yields:

$$TDM\ (t/ha) = GY + SY \quad [3]$$

Then after, the harvest index (HI) was calculated using the ratio of GY and TDM:

$$HI\ (\%) = (GY/TDM) \times 100 \quad [4]$$

Finally, plant vigor index (IV) was calculated using the circumference (C) of whole tillers as well as their high (H) according to Berchoux and Lecoustre (1986):

$$IV = \text{Log}\ [C^2 \text{ x } H)/4\pi)] \quad [5]$$

2-3) Soil sampling and analysis

After transferring 5 kg of soil in each of the pots, the soil was also sampled within 0 – 20 cm depth in surrounding position using hand augur and then, prepared for laboratory analysis. These analyses were including the determination of soil particle size contents, the pH, the contents in organic-carbon (C), total nitrogen (N), available phosphorus (P), potassium (K), zinc (Zn) and magnesium (Mg). Robinson pipette method was used for soil particle size analyze as described by Gee and Bauder (1986). Soil contents of C, N and P-available were determined by Walkley and Black (1934), Kjeldhal method and colorimeter after perchloric acid digestion (Olsen and Dean, 1965) respectively. The soil contents of exchangeable cations were by atomic emission spectrometry after extraction by ammonium acetate when Zn extraction also involved EDTA reagent (Norvell *et al*., 1996). The pH (water and KCl) were read using glass electrode in a mixture of 1/2.5 as soil/solution ratio.

2-4) Climatic data collection

Maximum and minimum air temperatures were recorded daily using a maxi/mini thermometer characterized by 0.5˚C in accuracy. Rainfall gauge was used determined rainfall amount while electronic hygrometer was used air moisture measurement.

2-5) Statistical analysis

GenStat package Discovery 3 was used for randomization of treatment in trial design. Wheat grain yield (GY), Straw yield (ST), harvest index (HI), vigor index (VI), high (H), numbers of tillers (Tiller) and panicles (Pan) were subject to analyze of variance (ANOVA) to assess treatment effects. The mean values were compared using least significant test (LSD) for α = 0.05. Pearson correlation was also performed in order to explore the relations between the GY and plant parameters as IV and HI for each treatment. These analyze are done by SAS package version 10.

3) RESULTS

3-1) Characteristics of soil and climate

The results of soil analysis are presented in table 1 showing that the trial was set on a sandy-clayed soil (sand = 79.1%; clay = 16%) characterized by 20 g/kg as C content which is twice lower than the threshold level (40 g/kg) coupled with enough level of (> 1 g/kg) of nitrogen which is 1.3 g/kg and high (> 10/1) C/N ratio however. Soil contents of exchangeable cations were 1.73 (< 2 $cmolkg^{-1}$), 0.45 (> 0.20 $cmolkg^{-1}$) and 0.09 (< 0.10 $cmolkg^{-1}$) for Ca, Mg and K respectively revealing Ca and K deficiencies and low ratios of Ca/Mg (3.84< 10) and K/CEC (0.014< 0.03). However, we noticed a low value of CEC (6.72 $cmolkg^{-1}$) below the threshold value of (20 $cmolkg^{-1}$) while high (> 2) value of Mg/K ratio (4.65) for a slight soil acidity (pH = 5.9) coupled with high contents of available P (> 10 $mgkg^{-1}$) and Zn (1 $mgkg^{-1}$) in the ranges of 25 $mgkg^{-1}$ and 19.32 $mgkg^{-1}$ respectively. In turn, ΔpH of +0.7 is asserting the importance of exchangeable anion capacity.

Figure 1 is showing the mean values of air temperature and rainfall amount recorded for different growing stage of wheat. Annual average temperature of 26˚35C was recorded while highest values (27˚5C) were observed in January, February, March and April along the year while lowest temperatures were always observed in August. Highest rainfall was occurring in June (700 mm) during the three years of experimentation contrasting with the lowest value observed in August (21 mm). The annual rainfall recorded during the three years was respectively of 2008 mm (2015), 2251 mm (2014) and 1551 mm (2013) as shown in table 2. Roughly, wheat growth was occurring between 26˚C and 25˚C during the last trial for a minimum values range of 23˚C and 24˚C. However, the annual mean value was increasing between 28˚C and 33˚C from the 1st to the last trial contrasting with the decreasing trend of 28˚C - 24˚9 C observed during panicle initiation stage.

Table 1: Soil physic-chemical characteristics in 0 – 20 cm depth

Soil properties	Value in 0 – 20 cm
pH_{water}	5.9
pH_{KCl}	5.2
Clay (%)	16
Coarse silt (%)	2.3
Fine silt (%)	2.6
Coarse sand (%)	63.6
Fine sand (%)	15.5
C-organic (%)	2
N (gkg^{-1})	1.3
P-available (ppm)-Olsen	25
K ($cmolkg^{-1}$)	0.097
Ca ($cmolkg^{-1}$)	1.731
Mg ($cmolkg^{-1}$)	0.451
Zn ($mgkg^{-1}$)	19.32
Mg:K	4.65
Ca:Mg	3.84
CEC ($cmolkg^{-1}$)	6.72
K: CEC	0.014

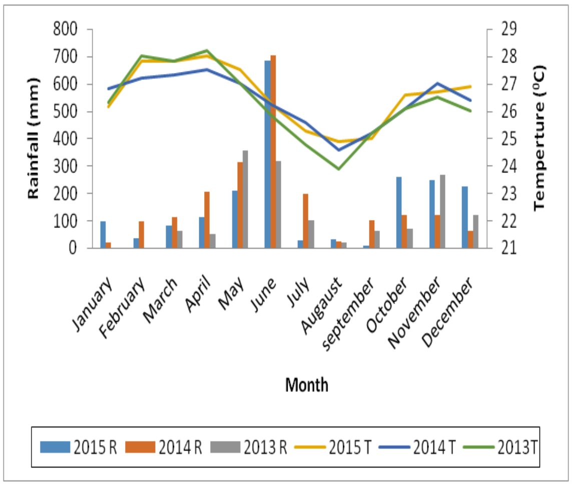

Figure 1: Temperature (T˚C) and rainfall (R) during the periods of trials (2013, 2014 and 2015)

Table 2: Average values of air temperature (T), rainfall amount (R) and hygroscopy (H) during the physiological stages of wheat according to the trials

	TRIAL 1			**TRIAL 2**			**TRIAL 3**		
	T (˚C)	**R (mm)**	**H (%)**	**T (˚C)**	**R (mm)**	**H (%)**	**T (˚C)**	**R (mm)**	**H (%)**
Germination	26	119.4	87	27	312.3	87.5	26.2	685	89.5
Tillering	28	1.6	86	26.2	702.6	90.3	35.3	27.7	90.1
Panicle initiation	28	1.6	86	25.6	198.3	88.7	24.9	29.8	89.8
Maturity	27.8	61.7	86.3	25.6	198.3	88.7	25	6.1	87.9
Minimum	23.9	0	85.7	24.6	20.8	84.2	24.9	6.1	80.1
Maximum	28.2	319.2	90.6	27.5	702.6	90.3	28	685	90
Average	26.3	119.3	87.90	26.4	173.2	87.85	25.5	153.9	86.7

3-2) Effects of treatments on wheat morphological parameters

Table 3 is showing the mean values of germination rate recorded on 7th and 17th DAS according to the treatments. Highest values of 100% were observed for the treatments NPK, NPKZn and NPKMg on 17 DAS. This value was also observed for the treatment NPK early on 7 DAS asserting a suitable condition of germination though the probability is not significant (P = 0.24 – 0.52).

Table 3: Germination rates on 7 and 17 days after germination

Treatment	Germination rate (%)	
	7 DAS	17 DAS
0-Control	66.7 bA	91 aA
Zn	67 bA	83 aA
Mg	75 baA	92 aA
NPK	100 aA	100 aA
NPKZn	83 baA	100 aA
NPKMg	83 baA	100 aA
NPKZnMg	83 baA	92 aA
P > F	0.24	0.52
CV (%)	30.28	17.59
Grand Mean (%)	79.76	94.05
$Lsd_{0.05}$	28.31	19.40

Letters a and b are indicating mean values with significant difference in column and line respectively

The mean values of leaf numbers on 10 and 17 DAS are presented in table 4 according to the treatments. Leaf number increasing is not significant within 10 days period of observation like treatment effect (P = 0.98; 0.86).

Table 4: Mean values of leaf number on 10 and 17 DAS according to the treatment

Treatment	**Leaf number per stand**	
	10 DAS	**17 DAS**
0-Control	2.3 aA	3 aA
Zn	2.5 aA	3 aA
Mg	2.3 aA	3aA
NPK	2.5 aA	3aA
NPKZn	2.3 aA	3aA
NPKMg	2.3 aA	3aA
NPKZnMg	2.3 aA	3aA
P>F	0.98	0,86
CV (%)	22.07	0
Grand Mean	2	3
$Lsd_{.005}$	0.61	0

Letters a (A) are indicating mean values with no significant difference in column and line respectively

There is significant (P = 0.002) increasing high of plant indifferently to the treatments of the trial (Figure 2). Low growth rate is observed between 22 and 45 DAS before an increasing growth rate up to 90 DAS. More details of this result is presented in figure 3: significant difference is occurring between the mean values and the highest value accounts for the treatment NPK characterized by a high value of 49.33 cm contrasting with the lowest values observed in NPKMgZn and the control treatment.

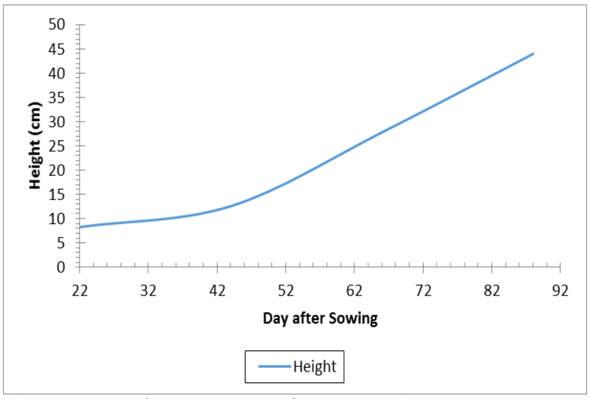

Figure 2: Growth rate in time scale (P = 0.002)

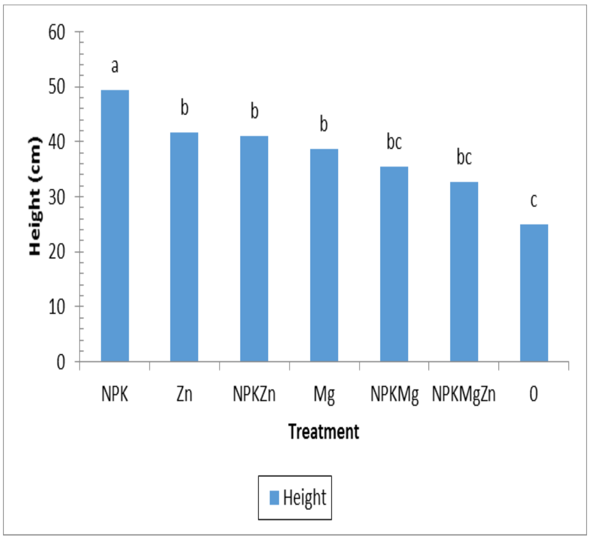

Figure 3: Mean values of plant heigh according to the treatments (P= 0.0001) [*Letters a, b and c are indicating the mean values with significant difference*]

The tiller numbers on 22, 44 and 66 DAS are keeping in table 5 respectively. Treatment effect is significant on 44 DAS (P = 0.029) and 66 DAS (P = 0.0002) contrasting with the result observed on 22 DAS (P = 0.54). Highest values are observed for the treatments NPKZn and NPKMgZn on 44 DAS (4 – 5 tillers/pot) and 66 DAS (8 tillers/pot) in similar ranges. The tiller numbers observed in treatments Mg and Zn are also similar to that of the control on each period of observation. About three weeks were required for treatment effect (fertilizer) while tiller number was limited to 2 tillers/pot during early period of 22 DAS.

3-4) Treatment effects on yield parameters

The rate of panicle initiation on 60 and 68 DAS as well as that of flowering on 68 and 76 DAS according to the treatments are presented in table 6 respectively. There is significant effect of treatment on each of the parameters. Moreover, there is significant difference between mean values indifferently to the studied parameters and dates of observation. The highest values of panicle initiation and flowering as observed on 60 and 68 DAS account significantly (P = 0.045) for the treatment Zn. However, highest value of flowering is significantly (P = 0.0002) observed for the treatment NPK later on 76 DAS resulting significant difference between mean values. Lowest values are often observed in the control treatment for both studied parameters while such results account for the treatment NPKZnMg later on 68 DAS referring to panicle initiation (65%) and flowering (63%) on 76 DAS respectively. However, the treatments Zn and NPK are almost relevant to highest rates recorded beside of NPKZn and NPKMg in some extend.

Table 5: Mean values of tillers per pot on 22, 44 and 66 DAS according to the treatment

Treatment	Tiller number /pot		
	22 DAS	44 DAS	66 DAS
0-control	2 aB	3 bcB	3 bA
Zn	2 aB	3 bcB	5 bA
Mg	2 aB	3 bcBA	5 bA
NPK	2 aC	5 aB	8 aA
NPKZn	2 aC	5 aB	8 aA
NPKMg	2 aB	4 baB	8 aA
NPKZnMg	2 aC	5 aB	8 aA
P > F	0.54	0.029	0.0002
C.V (%)	23.37	41	29.5
Grand Mean	2	4	6
$Lsd_{0.05}$	0.55	1.88	2.12

Letters a(A), b(B) and c(C) are indicating the mean values with significant difference in column and line respectively

Table 6: Panicle initiation rate on 60 and 68 DAS as well as flowering rate on 68 and 76 DAS according to the treatments

Treatment	Panicle initiation rate (%)		Flowering rate (%)	
	60 DAS	68 DAS	68 DAS	76 DAS
0-Control	4.17 bB	51.16 cA	4.17 bB	34.44 cA
Zn	45.56 aB	84.99 aA	40.50 Bb	74.99 baA
Mg	22.82 baB	77.18 baA	23.81 baB	70.63 baA
NPK	32.60 aB	70.38 baA	34.68 bB	82.18 Aa
NPKZn	29.50 aB	72.58 baA	30.55 aB	66.47 baA
NPKMg	34.92 aB	80.08 baA	27.29 aB	74.64 baA
NPKZnMg	30 aB	65 bcA	23.33 baB	63.33 bA
P > F	0.05	0.0046	0.049	0.0002
CV (%)	72.28	19.70	69.55	23.12
Grand Mean (%)	28.51	71.70	26.34	66.67
$Lsd_{0.05}$	24.15	16.07	21.48	18.07

Letters a (A), b (B) and c(C) are indicating the mean values with significant difference in column and line respectively

However, highest grain yields are observed for the treatments NPK and NPKMg with more pronounced trend for the treatment NPK significantly (Figure 4). The values recorded for treatments Zn and NPKZnMg are accounting among the lowest, similarly to the control treatment effect. Roughly, the yield is ranging threes time under mineral fertilizer effect.

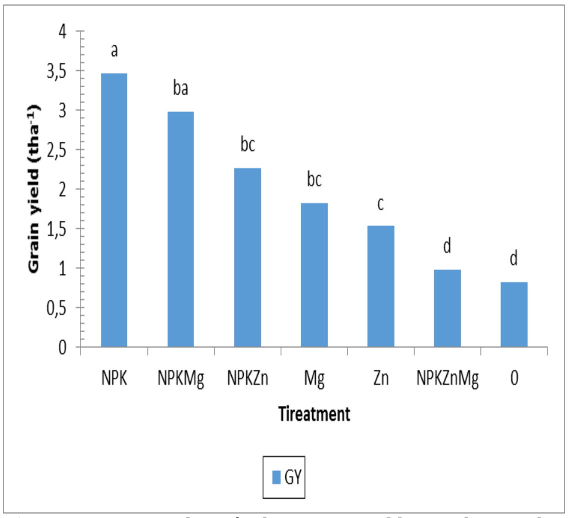

Figure 4 : Mean value of wheat grain yield according to the treatment (P = 0.0049)[*Letters a), b and c are indicating the mean values with significant*]

In turn, highest straw yield and total dry matter are recorded for treatments NPKMgZn and NPKMg as well as for treatment NPK in some extend (Figure 5):

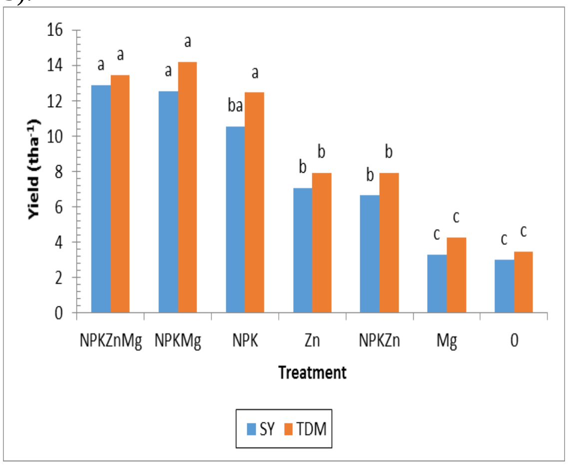

Figure 5: Straw yield (SY) and total dry matter (TDM) according to treatment (P = 0.0001) [*Letters a), b and c are indicating the mean values with significant difference*]

The mean values of HI, VI and root weigh are presented in table 7 according to the treatments. The treatment NPK has significantly (P< 0.0001 for VI and RW) induced the highest values of HI, VI and root weigh.

The relations between the grain yield (GY) and other parameters as HI and VI under mineral fertilizer effect are presented in Table 8 showing correlation coefficient (R) and its probability (P). The GY is significantly (P < 0.05) and positively impacted by HI and VI under effect of treatment NPK and NPKZn. In turn, only HI is positively correlated with GY for the treatments Mg, NPKMg and NPKZnMg in contrast with treatment Zn showing similar relation between VI and GY.

Table 7: Mean values of harvest index (HI), plant vigor (VI) and root weigh according to the treatments

Treatment	**Parameters**		
	HI (%)	**VI (%)**	**Root weigh (g)**
0-Control	11.75 ba	1.06 c	3.18 d
Zn	11.98 ba	1.61 ba	3.47 d
Mg	14.14 a	1.43 b	3.28 d
NPK	16.45 a	1.71 a	10.51 a
NPKZn	15.84 a	1.67 a	4.70 dc
NPKMg	11.70 ba	1.58 ba	7.05 bc
NPKZnMg	0.80 b	1.52 ba	8.26 ba
P > F	0.4712	0.0001	0.0001
CV (%)	107.5	13.14	43.34
Grand Mean **(%)**	15.23	1.51	5.78
ppds$_{0.05}$	19.20	0.23	2.93

Letters a, b and c are indicating the mean values with significant difference in column

Table 8: Pearson correlation between GY and the parameters HI and VI according to the treatments

Treatment	**Parameters**	**GY**	
		R	**P > F**
0-Control	**HI**	0.72	0.1082
	VI	0.52	0.2883
Zn	**HI**	-0.06	0.9062
	VI	0.85	0.0314
Mg	**HI**	0.95	0.0040
	VI	0.75	0.0856
NPK	**HI**	0.91	0.0130
	VI	0.90	0.0156
NPKZn	**HI**	0.99	0.0001
	VI	0.87	0.0255
NPKMg	**HI**	0.98	0.0005
	VI	0.27	0.6041
NPKZnMg	**HI**	0.94	0.0051
	VI	0.13	0.8197

4) DISCUSSION

4-1) Suitability of agro-ecological condition of the trial

The soil as substrate of the experiment has roughly low chemical fertility though carried out from underwood with high content of organic matter and C/N ratio of 15.2:1. The cation saturation rate of 31.26% is characteristic of high level of leaching as often encountered in forest zone under more than 1500 mm of rainfall (Avit *et al*., 1999). Fresh organic material (leaves and steam) supplying may account for the high rate of C/N (15.2:1) resulting high stock of carbon over the rate of mineralization. However, the soil is characterized by high turn-over of organic matter (Avit *et al*., 1999) as advocated by the suitable contents of N, P, Mg and Zn. In turn, Ca and K deficiencies were observed as consequence of high leaching characterizing the environment which might similarly affected Mg and Zn contents as cations. In fact, the soil is characterized by high Anion Exchangeable Capacity –AEC (ΔpH> 0) resulting more labile cations compared to anions as NO_3^- and $P_2O_4^{2-}$. As consequence, there is no need to supply N, P, Mg and Zn to the soil for plant growth. Well, it was noticed significant effect of such combination with K (NPKZn and NPKMg) on wheat reproductive parameters including panicle initiation and flowering. This result leads to hypothesizing their implication in reproductive hormone activities: Zn is involved in the synthesis of indol acetic acid which is an important growth regulator (Lamrani, 2010) and Mg is a component of chlorophyll for carbohydrate synthesis (FAO, 2005). However, the grain yield of NPKMg was higher than that of NPKZn and more pronounced higher than that of NPKZnMg characterized by lowest yield in similar range with that of the control. The treatments NPKZn and NPKMg have induced more biomass in above ground limiting the rhizogenesis as consequence of Zn or Mg supplying in addition to NPK which may positively impacted HI, VI and RW (Table 7). In fact, Zn and Mg are known to be involved in biosynthesis of β-indol acetic acid (heroauxin) constraining the activity of rhizocalin responsible for rooting (Miège, 1938). Overall, only NPK fertilizer is required on basis of soil diagnosis and wheat response. Nitrogen component as NH_4^+ (cation) and $P_2O_4^{--}$ fixation by Ca (Lamrani, 2010; Koné *et al.*, 2014) are justifying unavailability of these nutrients beside net deficiency of K (< 30% of CEC).

There was no significant effect of the treatments on wheat seed germination rate emphasizing the inopportunity of fertilizer requirement for wheat germination in the line of the results observed by Savage and Leubner-Metzger (2006) explaining the germination as emergence of radicles from the grain tegument. It is mainly influenced by soil moisture availability, oxygen and the temperature. The mean value of temperature (26˚C) and the monthly rainfall ranging between 153 and 173 mm during the trials might be suitable for wheat germination in the studied ecology excluding fertilizer effect (Table 3). In the light of wheat grain production under the extreme conditions observed for the temperature and air moisture (hygroscopy), the current study underline a chance to initiate wheat growing and production in similar ecology as the South Côte d'Ivoire.

4-2) Analyze of fertilizer impact

Except the germination rate, the treatments of fertilizer have significant ($P < 0.05$) effects on almost the studied parameters. Therefore, there is insight for the suitability of the studied ecology for wheat growth and fertilizer requirement. Well, a linear trend was observed for plant height (Figure 2) indifferently to the treatments. This result was mainly characterized by a maximum of 49.33 cm as plat height for treatment NPK (Figure 3) when highest values of about 90 cm were observed for wheat in others ecologies (Ali *et al*., 1992; Gate *et al*., 2003). Negative effect of photoperiodism was suspected when comparing to temperate climate conditions as origin of the studied cultivar: a reduction of sunlight duration can affect plant growth (Bennasseur, 2003). Other suspicion is related to the low rate of K (44 kgha^{-1}) as supplied by NPK (15% 22% 22%) regarding to its effect on plant growth and vigor (Lamrani, 2010) in the context of this experiment missing symptomatic deficiency of N and P. In main that current experiment was conducted under an average air temperature of 26˚C. Well, beside the stimulation of plant emergence, heat can activate tillering for an optimum rate over 20˚C (Marc Bonfils, 2011). In the mine time, this condition may be harmful for grain replenishment because of water used for inner temperature regulation against the grain filling (Robert *et al*., 1993).

However, up to 3.47 tha^{-1} were harvested as wheat grain under the effect of complex fertilizer NPK underling the importance of such fertilizer compound for wheat production in similar ecology of South Cote d'Ivoire. In fact, synergic effect of P and N under control of K, can affect the fecundation and carbo hydrate transport into the grains. This process can also act in the growth as well as quantity and quality of grains (Wopereis *et al*., 2008). Furthermore, combined effect of these nutrients has resulted highest root development, promoting high tillering and more fertile tillers. Therefore, more photosynthetic activity might occurred for maximizing solar energy transformation for biomass production as yield (Marc, 2001). The positive correlations presented in table 8 between grain yield and HI or VI and RW (R = 0.90) in treatment NPK were some illustrations of the assuming synergy between N, P and K for wheat mineral nutrition.

5) CONCLUSION

The results of current study pointed out the possibility to obtain a grain yield up to 3.47 tha^{-1} when applying a basal fertilizer only composed of NPK. A negative influence of photoperiod was observed beside that of the low rate of K being responsible of the tillering and the limited height. The presumed effect of Zn and Mg was suspected only during the reproductive stage without affecting the grain yield however because of limited development of the rhizosphere. Though the average grain yield of 3.47 tha^{-1} as observed with the treatment NPK is still low, there is opportunity to improve it by determining the optimum rate of NPK for wheat cultivation in a marginal zone of humid forest like the South of Côte d'Ivoire.

REFERENCES

Ali, D. T., Monneveux, P. and Araus, J. L. 1992.Adaptation à la sécheresseet notion d'idéotype chez le blédur. II. Caractèresphysiologiquesd'adaptation. Agronomie, EDP Sciences, 12(5), 381 – 393.

Amssa, M., Dekkaki, M., and Qariani, L. 2000.Identification descritères agro-physiologiquesd'adaptation du blédur aux basses températures et à la sécheresse. In :Royo C. (ed.), Nachit M. (ed.), Di Fonzo N. (ed.), Araus J.L. (ed.). Durum wheat improvement in the Mediterranean region: New challenges. Zaragoza: CIHEAM, 245 – 249.

Andreini, C. I., Banci, I., Bertin, I., and Rosato, A. 2006. Zinc through the trace domains of life. J. Proteome Res. 5, 3173 – 3178.

Avit, J.B. L. F., Pedia, P. L., and Sankaré Y. 1999.Diversitébiologique de la Côte d'Ivoire.Rapport de synthèse, 273 p.

Bajji, M. 1999. Étude des mécanismes de résistance au stress hydrique chez le blédur : caractérisation de cultivars différant par leursniveaux de résistance à la sécheresse et de variants somaclonauxsélectionnés In vitro. Thèse de doctorat.Univ . Louvain.

Barton, S. D., Nakanishi, K. and Meth-Cohn O. 1999.Comprehensive Natural Products Chemistry: Amino acids, peptides, porphyrins, and alkaloids, Volume 4. Elsevier.

Bennasseur, A., 2003. Référentiel pour la conduite technique de la culture du blédur
(Triticum durum Desf). Jour. of Agronomy, 2, 450– 455.

Berchoux, D. C. and Lecoustre R. 1986.Croissanceetdéveloppement du palmier à huile. Chapitre II. De la germination à l'entréeenrécolte. La Mé : CIRAD-IRHO.

Boyer, J. 1982.Les sols ferralitiques. Tome X. chapitreonze :Facteurs de fertilité et utilisation des sols, OSTROM, Paris, 237 – 270.

Bruijn, M. and van Dijk, H. 2006.Climate change and climatic variability in Africa. Africa study center, ASC Info Sheet 2. Available at: http://www.ascleiden.nl/Pdf/infosheet 2.pdf [february 16th 2016].

Celement, J.M., 1981. Larousse agricole. Edition : S.P.A.D.E.M. et .A.D.A.G.P. Paris Vol. 177, N° 1032, 171 – 174.

CIMMYT. 2015. Wheat for Afica in number. Disponible sur :http://wheat.org/wheat-for-africa/[15 février 2016]

Desheva, G. 2016. Effects of Genotype, Environment and their Interaction on Quality Characteristics of Winter Wheat. J.basic appl.Res 2 (3): 363 – 372.

Dugué, M.J. 2012. Stratégie d'adaptation au changement climatiqueen agriculture paysanne : Etude de capitalisation réalisée sur les terrains de coopérationd'AVSF. Agronome et vétérinaires sans frontière.

FAO. 2005. Notions de nutrition des planteset de fertilisation des sols, Manuel de formation. Projet b Intrants, 24 p.

Finch-Savage, W. E. etLeubner-Metzger, G. 2006. Seed dormancy and the control of germination.New Phytologist, 171, 501-523 Gate P., 1995. Ecophysiologie du blé : de la plante à la culture. Tec &Doc, Lavoisier

Gate, Ph., Giban, M., Blondlot, A., Braun, Ph., Graund, G., Jouy, L., Laurent, F., Lutton, A. etVignier, L. 2003. Stades du blé.Edition ITCF.

Gee, G. W. etBauder, J. W. 1986. Particle-size analysis.Dans G. S. Campbell, R. D. Jackson, M, M. Mort-land, D. R. Nielson, et C. A. Klute, eds. Methods of soil analysis. Part 1, Physical and mineralogical methods, 2ième ed. Agron, 9, ASA, SSSA, Madison,WI, 383 – 423.

Godefroy, J., Muller, M. etRoose R. 1970. Estimation des pertes par lixiviation des Clémentsfertilisantsdansun sol de bananeraie de basse Côte d'Ivoire. Fruits (Paris), 25, (6), 403 – 420.

Karabaghli, C., Sotta, B. et Gay, G. 1997. Hormones fongiques, ectomycorhizesetrhizogénèse. Rev. For. Fr. XLIX -n° sp, 99 – 109.

Khelil, M. B., Bouhlal, R. etHellali, R. 2013. Utilisation des GibbérellinescommeFacteur de Remodelage du cycle fructifère du citronnier 'Euréka' (Citrus limon L.). Journal of Applied Biosciences 66:5162– 5172, ISSN 1997–5902.

Koné, B., Kouadio, K.H., Cherif, M., Sylvester Oikeh, S., Akassimadou, EF., Yao, GF.et Konan, K.F. 2014. Rice Grain Yield Gap and Yield Declining as Affected by Different Phosphorus Fertilizers in Acid Soil Over Successive Cropping Seasons. International Journal of Biological Sciences, 1 (1), 21 – 43.

Koné, B., Ettien, J. B., Amadji, G. etDiatta S. 2008. Caractérisation de la tolérance de NERICA à la sécheresse de mi-saisonenriziculturepluviale. African Crop Science Journal, Vol, 16, No, 2, 133 – 145.

Lamrani, Z. 2010. Nutrition minéraleetazotée (PhysiologieVégétale). EcoleNormaleSupérieure, Département des Sciences de la Matière et de la vie, 51 p.

Lacock, L. and Botha, A. M. 2000.Genotype variation in regeneration and transient expression efficiencies of 14 South African wheat cultivars.South African Journal of Plant and Soil,17(4), 170 –174.

Mackill, D. J., Coffman, W. and Rutger, L. J. 1982.Pollen shedding and combining ability for high temperature tolerance in rice.*Crop Sci.*20, 730 – 733.

Marc, Bonfils. 2011. Permaculture: Recherches de Marc Bonfils, Erudihen, 171 p.

Marc, L. 2001. Le plant de riz, Données morphologiques et cycle de la plante. Mémento Technique de Riziculture, Fascicule 2, 22 p.

Miège, E. 1938. Etude du développement du systèmeradiculaire du Blé (Suite et fin). In: Revue de botaniqueappliquéeetd'agriculturecoloniale. 18e année, bulletin n°202, 420 – 426.

Munang, R. et Andrews J. 2014. L'Afriqueface aux changementsclimatiques. Afrique Renouveau: ÉditionSpéciale Agriculture 2014, 6 p.

Norvell, W. A. and Lindsay, W. L. 1969.Reaction of EDTA complexes of Fe, Zn, Mn and Cu with soils.Soil Sci. Soc. Amer. Proc. 33, 86 – 91.

Olsen, S. R. et Dean, L. A. 1965. Phosphorus in C, A, Black, ed. Methods of soil chemical analysis.Part 2, Agron, 9, ASA, Madison, WI, 1035 – 1049.

Robert, D., Gate, Ph. etCouvreur, F. 1993. Les stades du blé.Edition.ITCF, 28 p.

Saley, M. B., Tanoh, R., Kouamé, K. F., Oga, M. S., Kouadio, B. H., Djagoua, E. V., Oulare, S., Youan, T. M., Affian, K., Jourda, J.P., Savane, I. et Biemi, J. 2009. Variabilitéspatio-temporelle de la pluviométrie et son impact sur les ressourceseneauxsouterraines :cas du district d'Abidjan (Sud de la Côte d'Ivoire), 18 p.

Scott, B.J. and Robson, A. D. 1990. Changes in the content and form of magnesium in the first trifoliate leaf of subterranean clover under altered or constant root supply. Australian Journal of Agricultural Research, 41, 511 – 519.

Walkley, A. et Black, I. A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci, 37, 29 – 38.

Whitmore, T.C. 1998. Potential impact of climate change on tropical rain forest seedlings and forest regeneration.Climatic Change, 39, 29 – 438.

Windmeijer, P. N. 1993. Inland valley in WestAfrica: An agro-ecological characterization of rice-growing environnements. IILRI Publication 52, Wageningen39, 429 – 438.

Wopereis, I., Brand-Gruwel, S. and Vermetten, Y. 2008. The effect of embedded instruction on solving information problems. Computers in Human Behavior, 24, 738 – 752.

Zadoks, J., Chang, T., and Konzak, C. 1974. A decimal code for the growth stages ofcereals. *Weed research*, 14(6), 415 – 421.

Zheng, K.L. and Mackill, D. T. 1982. Effect of high temperature on anther dehiscence and pollination in rice.*Sabrao J.*14, 61 – 66.

Zouaoui, A. and Bensaid, R. 2007. Détermination des exigencesclimatiques du blédur (Triticum durum Desf. var. Mohamed Ben Bachir) en zone semi-aride. Cahiers Agricultures 16 (6), 469 – 476.