Effect of Microorganisms solubilizing Phosphorous on growing plants Maize (*Zea mays*) in Adamawa-Cameroun

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ABSTRACT

Aims: Aims of this study was to improve the growth of Maize (*Zea mays*) in the Adamawa region specially characterized by Sudano-Guinean and Sudano-Sahelean savannah area.

Place and Duration of Study: Study was conducted out on Jun 2021 in Bini-Dang, in order to identify suitable strains of microorganisms solubilizing phosphorus (MSP) of roots and rhizosphere of *Zea mays*. Ten strains of microorganisms solubilizing phosphorus (MSP) of roots and rhizosphere of *Zea mays* were sampled.

Methodology: The experimental design was three blocks completely randomized with 132 plots. A total of 11 treatments were considered during the experiment. Different treatments are constituted: BN, NBB, BNB17, RBNBB5, SSL9, SDB6, RKB1, BG12, SDL4, RDB1 and Control) repeated 12 times. Parameters were: germination time, number of leaves, height of plants, diameter of stem, date of flowering and the number of cobs per plant.

Results: Our results showed that Bacteria solubilizing phosphorous was significantly ($P<0.05$) improve yields of plants compared to non-inoculated control in all treatments. Germination time, the number of leaves, the height of plants, the diameter of stem, the flowering and the number of cobs per plant were statistically ($P<0.05$) most important with uses of strains microorganisms solubilizing phosphorous in block 2, which received Natural phosphorus (NP) and inoculated by microorganisms solubilizing Phosphorous in the block 3 (inoculated with MSP).

Conclusion: Strains of MSP improves the germination, growing and number of cobs per plants of Zea mays in solubilizing Natural phosphorous (NP). The strains of MSP, BNB7, BNB17, RBNB5, BN and SDB6 were significantly most performants, compared to others strains effect on field. The MSP could be used as biological fertilizers by direct application on soils with Natural phosphorous (NP).

Keywords: Microorganisms, Rhizosphere, Zea mays, Natural phosphate (PN), Adamawa.

1. INTRODUCTION

Intensification cultures during these 30th years has caused an important use of nutrients elements on tropical soils (Gagnon et Beaulieu, 2002). Problems degradation of soil quality and proliferation of some diseases providing to the uses of intense chemical fertilizers are serious now. Environmental questions are now correlated to human's factors, the protection of naturals resources is one of priority and many environmental problems need new agricultural practices suitable (Demers, 2008).

The decrease of soil fertility is a fundamental problem which limit the productivity of plants (Tokty, 2012). These problems are serious in tropical and subtropical countries where soils are generally washed during rainy and inondations, exposed nutrients of soils (organic matter). In these soils, the productivity of plants is limited in the one hand by soil acidity, lower capacity of plants to take nutrients and dryness effects (Mohamed, 2012). Taking in account phenomenon of washing which causes loss of phosphorous, the heavy metals presents in high quantity on soils considerably sequestrates phosphorous available as form some sediments (AlPO4, FePO4, CaPO4) not absorbable for the plants (Gyaneshwar *et al.,* 2002), which justify that the lower quantity of phosphate fertilizers available for plants in soils. Considered as second major nutrients elements of agricultural production after Nitrogen (Ehrlich, 1990; Bado, 2002), the necessity to preserve these available for plants is primordial.

Nowadays, intensive agriculture by the uses of chemical fertilizers could be a problem for the durability of natural resources (Demers, 2008). Uses of pesticides and chemical fertilizers causes the destruction of soils Fauna, good and essential of soils ventilation. However, scientific community give importance on preservation of ours resources with the respect of environmental concept, human's health and the valorization of biological fertilizers such as rhizobia, mycorrhiza and microorganisms solubilizing phosphorous (MSP). In fact, uses of biological fertilizers, phosphate fertilizers are now indispensable, due to their good effect on production (quantity and quality). Phosphorous is one element which is largely distributed on nature. It is considered with Nitrogen (N) and Potassium (K), as a fundamental component of life of plants. Many research through the world on fertilization were showed the primordial role of phosphorous on mineral nutrition of plants. Knowing that Nitrogen constitute one fundamental element on growing and developing plants, phosphorous contribute on photosynthesis and respiration of plants (Mihoub, 2012).

Adamawa land is one area where all potentialities are available for the implementation of agricultural activities. Topography of this area is constituted of vast extensive land with suitable rainy seasons. However, these land are exposed and degraded by anthropic factor's, fire bush, inadequate cultural practices, bad uses of chemical fertilizers and washing effect due to rain. Physical and chemical nature are for the majority acids, clayey which influences soils fertility. Maize, as one of major food for several populations of Cameroon is an income product of these area. According to the Regional Delegation of Rural and Agricultural Development of Adamawa, yields of maize are lower and not exceeds one ton/ha (800 kg) on rural agricultural plantations without fertilizers.

Improvement of yields must be done by the uses of organic and inorganic fertilizers which contributes on preservation of vegetal resources. In order to limit these problems of low production due to the decrease of soils fertility (deficiency of phosphorous for plants), microorganisms solubilizing phosphorous (MSP) contributes on solubilizing phosphorous needed and available for plants. Acknowledges on experimental work is now primordial and important on soils fertility. Several works were conducted on the effect of microorganisms solubilizing phosphorous. These research were done on isolation, characterization and the test of strains in sterile middle, but none study was realized with strains of MSP in real middle. These strains are available now for rural in real middle where the importance of this study. Aims of this study is to evaluate the impact of MSP on growing of Maize (*Zea mays*) on Adamawa area.

I- MATERIALS AND METHODS

I.1. DESCRIPTION OF STUDY

The study was conducted on the locality of Bini-Dang situated at 15 kilometers of Ngaoundere town (Figure 1). For this study, one site was chosen within the Campus of University of Ngaoundere. The geographical coordinates of area are: 7°42'36" of latitude North; 13°54'24" of longitude East and 1106 m of altitude. This site is not being used since two years (Fallow) after cotton culture. Soil chemical analysis revealed that it is acid with the high quantities of iron (192.0 mg/kg), aluminium (93.89 mg/kg) and calcium (12.08mg/kg). Available quantities of phosphorous (12.35mg/kg) is low with explain the acidity of this soil.

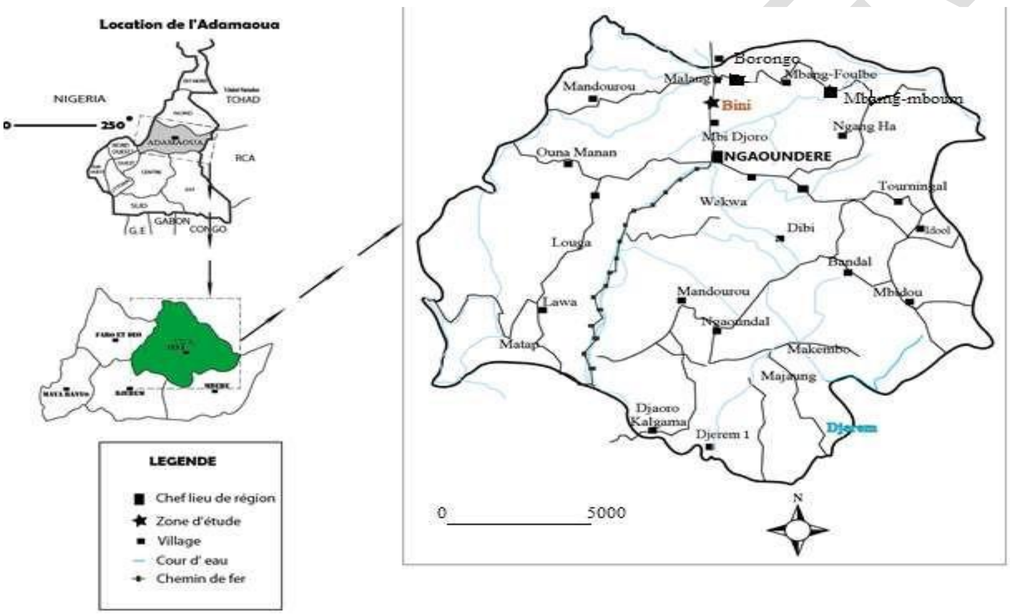


Figure 1: Localization Map of Ngaoundere

I.2. BIOLOGICAL AND VEGETAL MATERIAL

The variety SHABA of Maize (*Zea mays*) was used (picture 1), providing from Regional Delegation of MINADER.

Picture 1: *Zea mays* variety SHABA

Natural phosphate used come from locality of Hangloa (Picture 2) characterized by the sedimentary structure: vivianite with a high percentage of solubility and mineralogical composition of Fe_2O_3 (68.72 %); P2O5 (9.17 %); Al2O3 (7.72 %) and SiO_2 (9.67 %) (Fodoué, 2012).

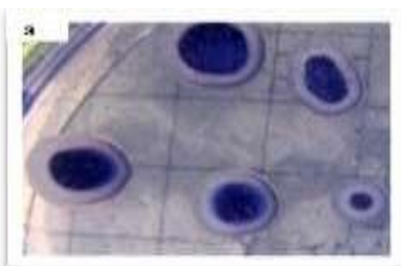
Picture 2: Vivianite (Fodoué, 2012)

I.2.1 MICROORGANISMS SOLUBILIZING PHOSPHOROUS (MSP)

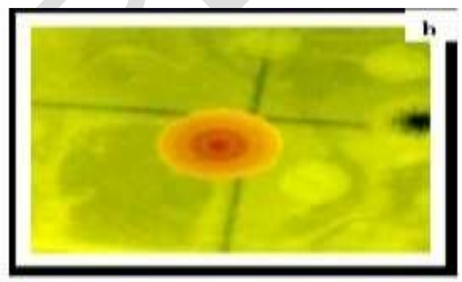
Microorganisms with solubilizing phosphorous (MSP) come from soil and root rhizosphere of *Zea mays* on the locality of Sudano-guinean savannah and Sudano-sahelean of Cameroon. Sample code of MSP is presented on table 1.

Table 1: Code isolated from Microorganisms Solubilizing Phosphorous according to different sites.

Localities	Codes
BINI	BN
MBANG-MBOUM	BNB, RBNB5, BNB17
SOIL SALAK LABOUR	SSL9
ROOT BURNT OF KONGOLA	RKB1
BORONGO	BG12
SOIL DOKBA LABOUR	SDL4

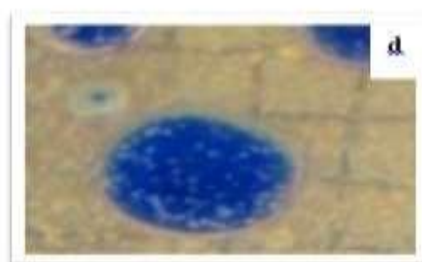


Solubilisation BN avec du CaPO4



Solubilisation de BN avec du FePO4

Solubilisation de BN avec du PN



BG12 pas de halo de solubilisation

Picture 3: solubilizing process on solid middle of some isolated from MSP

I.2.2 MYCORRHIZA INOCULUM

Inoculum process is constituted of mixture of soil (sand) and spores of fungus of genus Glomus and Gigaspora with a concentration of 20 spores/g of substrate.

Picture 4: Mycorrhizal inoculum

II. METHODS

II.1 SAMPLE PROCESS OF SOIL AND PROCEDURE OF OBTAINED ASH ROCK

Soil used come from the locality of Ngaoundere, precisely of Bini-Dang. The sample of soil provides to organo-mineral horizon (0-25cm). Composite samples taken around the experimental site consist to take diagonally the sample on the plots. After taking the soil, a mixture of 2000 kg was done and 5kg of this soil was taken with a scales in order to fill on the bags with size of 50cmx30cm. One quantity of soil is used for physico-chemical analysis. In laboratory, phosphate rock is crushed using hammer and mashed, sieved with the size mesh of 75µm for obtain powder.

II.2 EXPERIMENTAL DESIGN AND INOCULATION OF PLANTS BY MSP

Ten isolates sample: BN (B1), BNB(B2), BNB17(B3), RBNBB5(B4), SSL9(B5), SDB6(B6), RKB1(B7), BG12(B8), SDL4(B9) and RDB1(B10)) were chosen according to their ability to solubilize phosphorous. These sample were cultivated using Erlenmeyers of 250 mL with contain 50mL of liquid middle (Nutrient Broth) on agitator of ambient temperature. Before sowing, seeds of corn were sterilized superficially in alcoholic at 70 % during 2 minutes. After that, they were involved on bleach during 15 minutes and washed 10 times on sterilized water. Inoculation process was done by taken 1 mL of inoculum with syringe for spraying on the soil plots. Different plots were arranged in three blocks of 132 plots every one. Eleven treatments were randomized (BN, BNB, BNB17, RBNBB5, SSL9, SDB6, RKB1, BG12, SDL4, RDB1 and control (T)) repeat 12 times (Figure 2). Control treatment are constituted of non-inoculated pockets. Blocks 1 contain 50g of rock powder + 10g of mycorrhiza, adding with bacterial inoculum in every one of pockets. Blocks 2 contain 50g of rock powder on plots adding with inoculum. On block 3, only inculated strains of mycorrhiza was used. Inoculation and incubation of rock powder were done during sowing:

- 1er block: MSP +Mycorhises + PN

- 2nd block: MSP + PN

- 3th block: MSP

After sowing seeds of *Zea mays*, some parameters were evaluated: germination time, number of leaves, height of plants, diameter of stem, date of flowering and the number of cobs per plant.

II.3 DATA ANALYSIS

Data collected were analyzed with software « Statgraphic plus version 5.0 » which perform the ANOVA and determine the interactions within treatment. Test of Duncan were used to determine the difference among average of treatments.

III. RESULTS

III.1 INFLUENCE OF MSP ON SEEDS GERMINATION OF MAIZE

Germination rate of corn were recorded after 4 days for all isolated strains of MSP (Table 2). They are constituted of isolated strains of BNB17, BNB et RBNB5 on block 3 and the treatment SDB6, BNB17, BG12, and RDB1 on block 2. RKB1 treatment show a highest germination limit which not impact germination time on the block 1 and 3. ANOVA showed a significant difference (p=0.000) among treatment in all the blocks.

Table 2: Seeds germination limit of Maize according to treatments

Strains	**Block1**	Strains	**Block2**	Strains	**Block3**
BNB	5±0.14a	**SDB6**	4.16±0.16a	**BNB17**	4.25±0.15a
SSL9	5.83±0.14b	**BNB17**	4.66±0.16b	**BNB**	4.83±0.1b
RDB1	5.91±0.14b	**BG12**	4.75±0.16bc	**RBNB5**	4.83±0.15b
BN	6±0.14b	**RDB1**	4.91±0.16bc	**SDB6**	5.33±0.15c
BNB17	6±0.14b	**BN**	5±0.016bc	**BN**	5.41±0.15cd
SDB6	6±0.14b	**BNB**	5±0.16bc	**SDL4**	5.58±0.15cd
BG12	6.08±0.14bc	**SSL9**	5.16±0.16cd	**BG12**	5.66±0.15cd
RBNB5	6.41±0.14c	**SDL4**	5.5±0.16de	**RDB1**	5.66±0.15cd
Control	6.41±0.14c	**RBNB5**	5.66±0.16e	**SSL9**	5.83±0.15d
RKB1	7±0.14d	**RKB1**	5.66±0.16e	**Control**	6.41±0.15e
SDL4	7±0.14d	**Control**	6.25±0.16f	**RKB1**	6.5±0.15e
Probabilities	P=0.0000		P=0.0000		P=0.0000

NB: Values of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤ 0.05) (Test de Duncan).

III.2 EVOLUTION OF NUMBER OF LEAVES PER PLANTS OF MAIZE.

Number of leaves were determined on July 2021. The number of leaves recorded during the month August varied from 10 to 12 leaves on block 1, 10 to 14 on block 2 and 09 to 13 on block 3. The number of leaves were significant differed in all block within the first month and second month, contrary to the third month. ANOVA test on block 1 showed a highest significant difference among isolated strains and average number of leaves (p=0.0033) in the first time, and those of block 2 and 3 showed a high significant difference with p-values varied respectively from 0.0000 to 0.0001. Inoculation of isolated strains of MSP improve the number of leaves of Maize. In the lasts blocks, the highest number of leaves were recorded on treatment BN, followed by BNB and BNB17 which treatment generally improve number of leaves. The strains BN, RDB1 and SDL4 improves the number of leaves on the block 1, contrary to others strains (RBNB5, BNB17, SSL9, SDB6 et BG12), compared to control (Figure 3).

III.3 EFFECT OF INOCULATION STRAINS OF MSP ON MAXIMAL DIAMETER

Figure 3 reveal the maximal diameters of plants obtained at 90th days after sowing. They varied from one block to others according to this order: block2>block3>block1.Within every block, we recorded a significant difference between strains of MSP and diameters of plants. The highest diameters were obtained with treatment BN, BNB, BG12 and SDL4 in block 1. The others treatments have the values approximatively equals to control. In block 2, the strains of MSP were positively affect the diameters and are significantly different (P≤ 0.05) to control, which is similar to block 2.

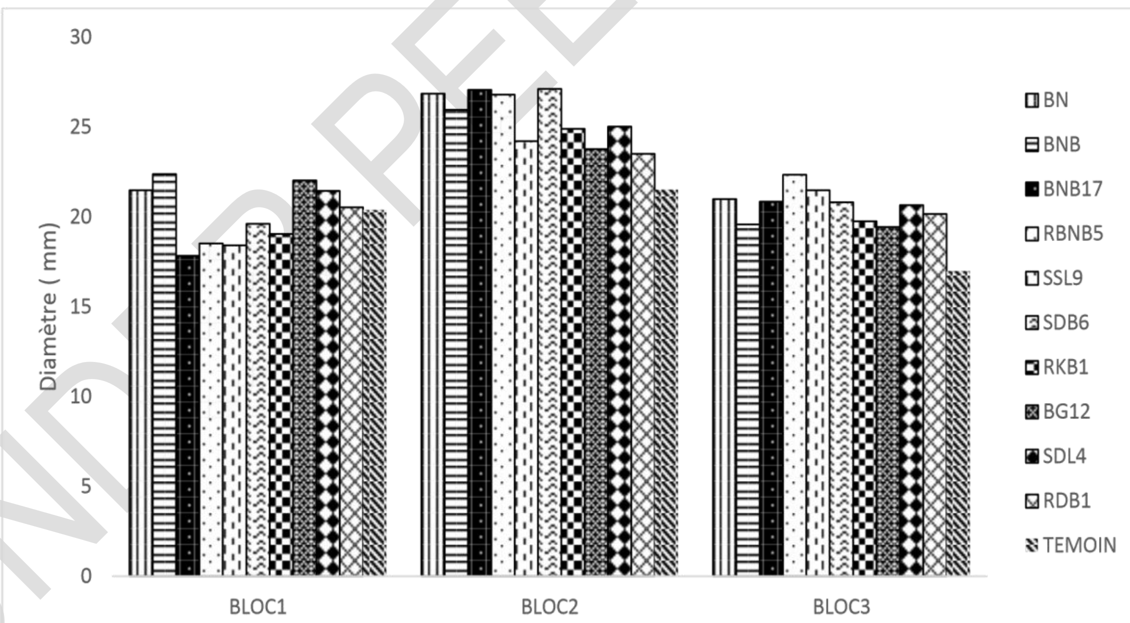


Figure 2: Maximal diameters of plants Maize at 90^{th} days after sowing on different blocks.

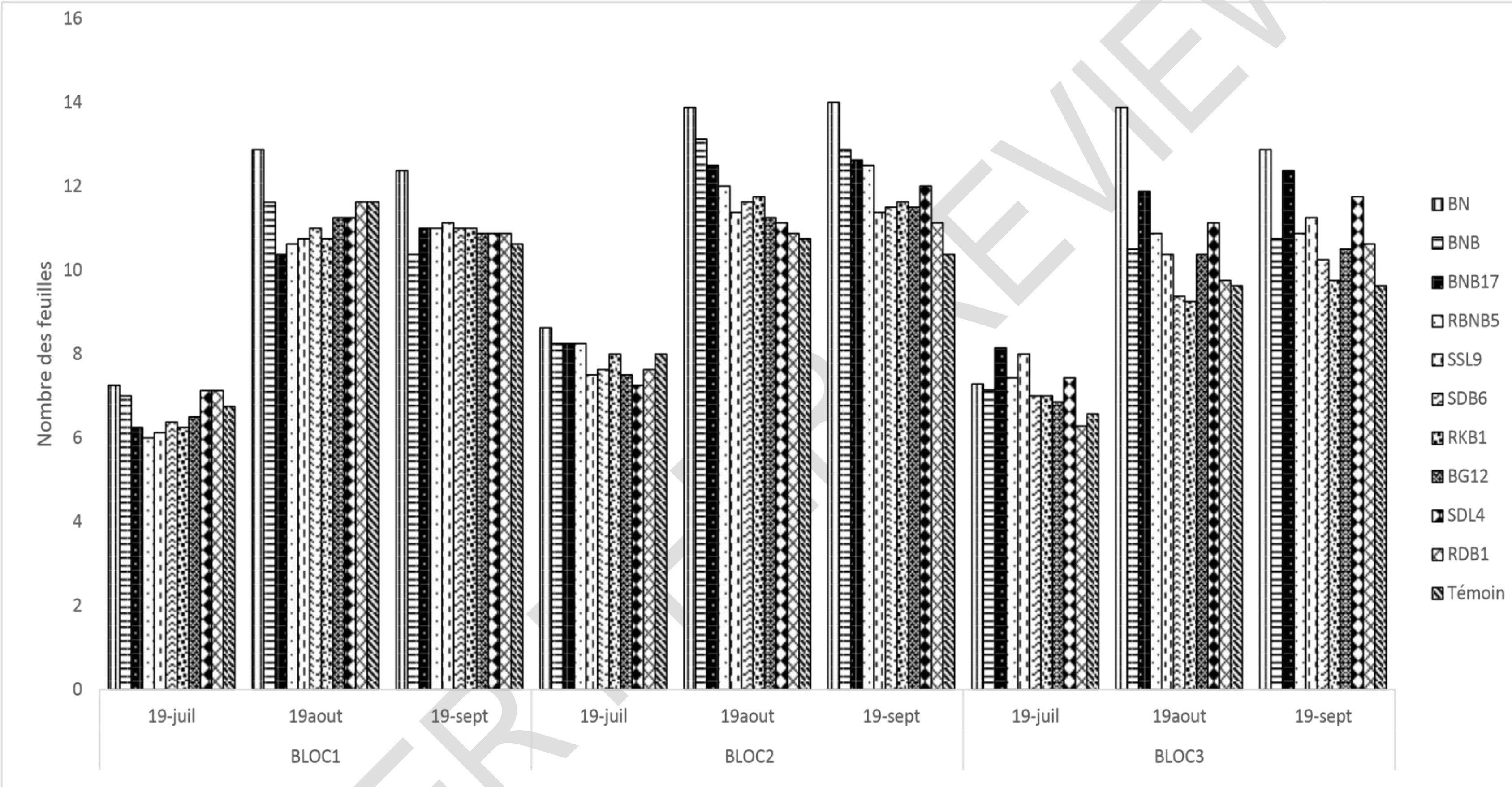


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Figure 3: Evolution of number of leaves per plant according to the blocks.

III.4 EFFECT OF MSP ON GROWING PLANTS MAIZE

III.4.1 HEIGHT OF PLANTS AT 90 DAYS AFTER SOWING

Average height of plants for every strains of MSP is presented on table 3. We recorded after three months of growing, a significant difference (p<0.01) between strains of MSP and average height of plants for the block 1 with p-value equal to 0.0003. The treatments with isolated strains of MSP generally influences the height of plants maize and presents the values which are significantly different to control. In block 2, we recorded a highest significant difference (p=0.000) within the strains and the average height of plants Maize. All strains of MSP positively improves the growing of Maize, compared to control. High values were recorded with the strains BNB17 (66.80) et SDB6 (66.26). Block 3 reveal a significant difference between treatments and average height of Maize (p<0.01) and similarly, we observed a significant difference among strains treatment and control.

Table 3: Height variation of plants Maize according to treatments three month after sowing.

Strains	Height (cm) **Block1**	Strains	Height (cm) **Block2**	Strains	Height (cm) **Block3**
Control	43.45±2.53a	**Control**	54.97±2.00a	**Control**	42.91±1.789a
RBNB5	51.09±2.53ab	**RKB1**	55.72±2.00ab	**RDB1**	46.45±1.78ab
SSL9	51.5±2.53abc	**BN**	57.58±2.00abc	**BG12**	48.15±1.78abc
RKB1	51.66±2.53abcd	**BG12**	58.77±2.00abc	**SDL4**	49.05±1.78bcd
BNB17	52.70±2.53bcd	**SDL4**	61.07±2.00bcde	**RKB1**	50.56±1.78bcde
RDB1	55.25±2.53bcd	**RDB1**	61.44±2.00bcde	**SDB6**	50.7±1.78bcde
BG12	56.83±2.53bcd	**BNB**	62.35±2.00cd	**BNB**	51.37±1.78bcde
SDB6	57.04±2.53bcd	**SSL9**	63.06±2.00cde	**BNB17**	53.41.11±1.78cde
SDL4	59.72±2.53cd	**RBNB5**	63.11±2.000cde	**RBNB5**	54.11±1.78de
BN	61.82±2.53de	**SDB6**	66.26±2.00de	**BN**	54.65±1.78e
BNB	66.69±2.53e	**BNB17**	66.80±2.00e	**SSL9**	55.6.54±1.78e
Probability	P=0.0003		P=0.000		P=0.0018

NB: Values of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤ 0.05) (Test de Duncan).

III.4.2 EFFECT OF MSP ON EVOLUTION OF HEIGHT OF PLANTS MAIZE ON BLOCK 1

Growing process according to time is illustrated on Figure 4. This graphic shown highest evolution of height of plants and the decreased of growing relatively traducing flowering process and fructification. These result could be explaining by the use of nutrients elements contained on the bags. We recorded also the highest growing with strains BNB (92.5 cm) and the minimal height was 57.75 cm obtained in non-inoculated plots. The others strains relatively show the same growing.

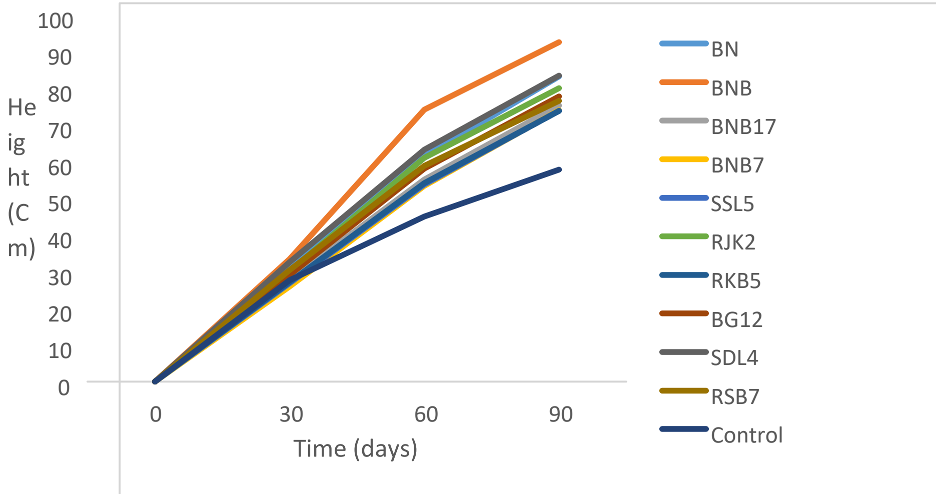


Figure 4: Effect of microorganisms on growing of plants Maize three month after sowing on block 1.

III.4.3 EFFECT OF MSP ON EVOLUTION OF HEIGHT OF PLANTS MAIZE IN BLOCK 2

Figure 5 illustrate growing of plants which are highest with strains SDB6 (96.08 cm) BNB17 (92.2). Minimal heights are obtained with treatments BG12 (76.68cm) RKB1 (77.07cm) and Control (78cm). The others strains relatively show the same height.

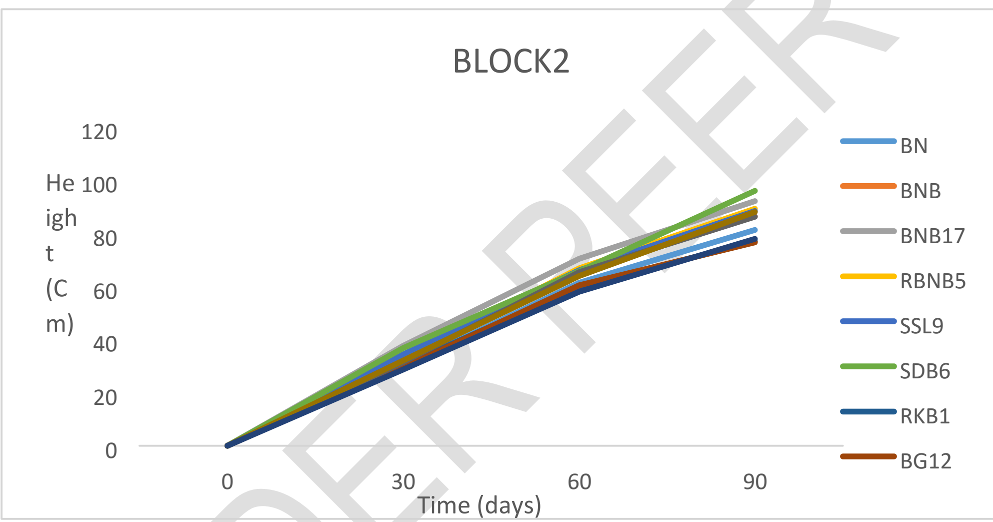


Figure 5: Effect of microorganisms solubilizing phosphorous on evolution of plants Maize on Block 2.

III.4.4 EFFECT OF MSP ON EVOLUTION OF HEIGHT OF PLANTS MAIZE IN BLOCK 3

Similar observations were made on block 3 showing the same height of treatments, compared to non-inoculated control (Figure 6). The BNB17 and SDB6 strains most improves height of Maize.

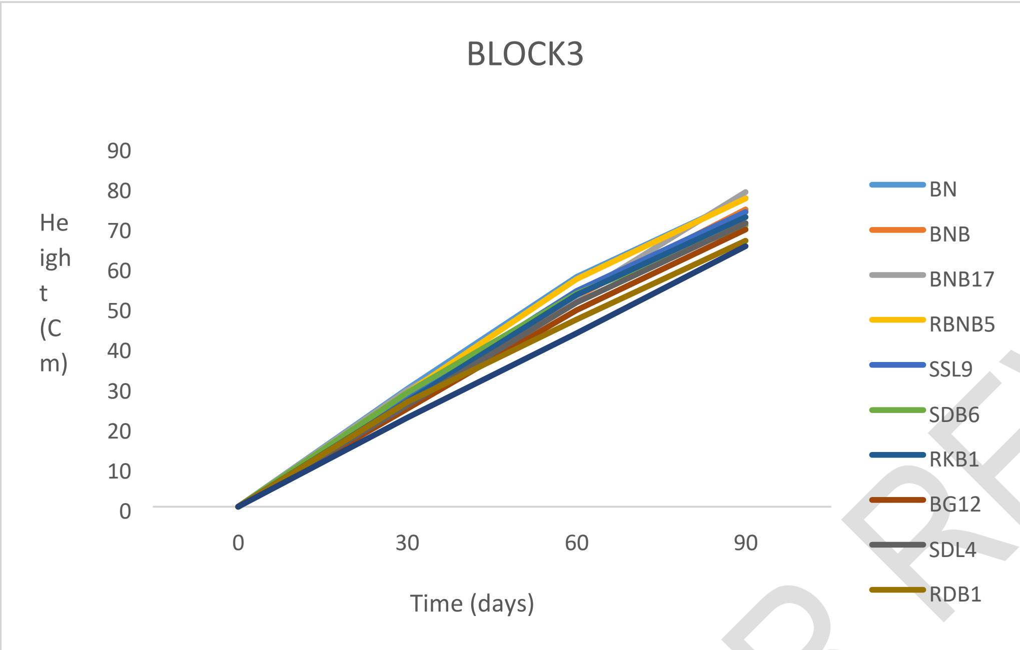


Figure 6: Effect of microorganisms solubilizing phosphorous on evolution of plants Maize in block 3.

III.5 EFFECT OF MSP ON MALE FLOWERING

III.5.1 EVOLUTION OF FLOWERING DURING TIME

Flowering process was determined during date. These evaluation was evaluated at 68th days after sowing. Block 1 on the figure reveal that since the first time of taking data, we not recorded flowering of plants. At 68th days, we observed a difference of flowering between treatments on block 2 of strains BN, BNB, BNB17, BG12. Similarly, on the block 3, only the strains RBNB5 flowered at 80th days among the twelve repetitions. Contrary to others block, this graphs (Figure 7) showed effective difference on number of male flowers during the third weeks of flowering for the three blocks. These permit to classify according to the order: block2> block1> block3. For all the blocks, the numbers of control treatments are low to others treatments.

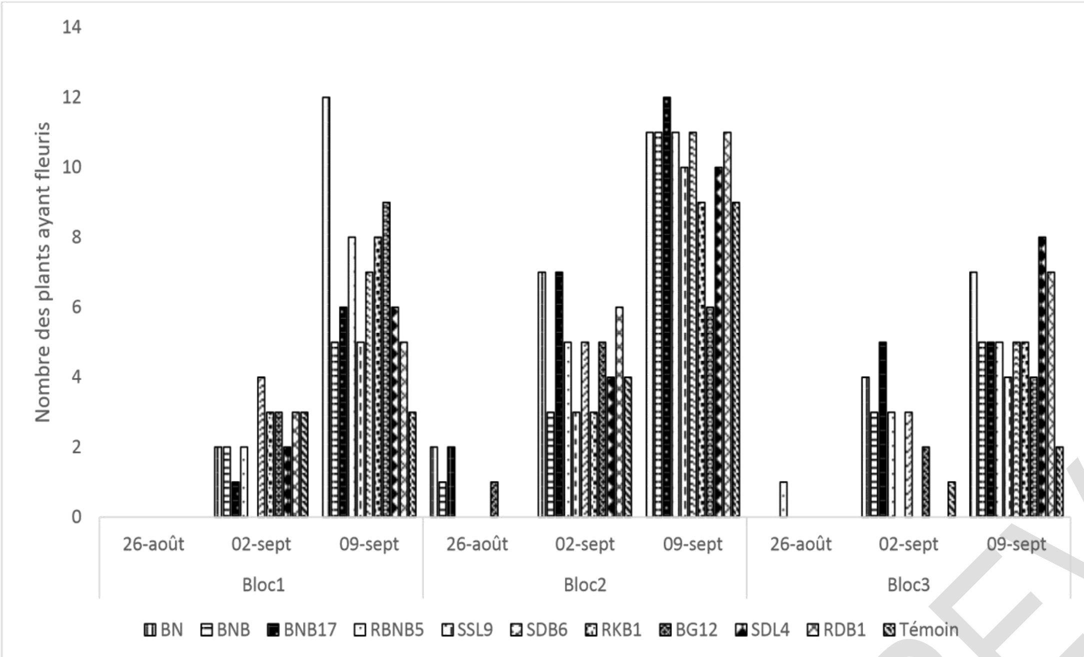
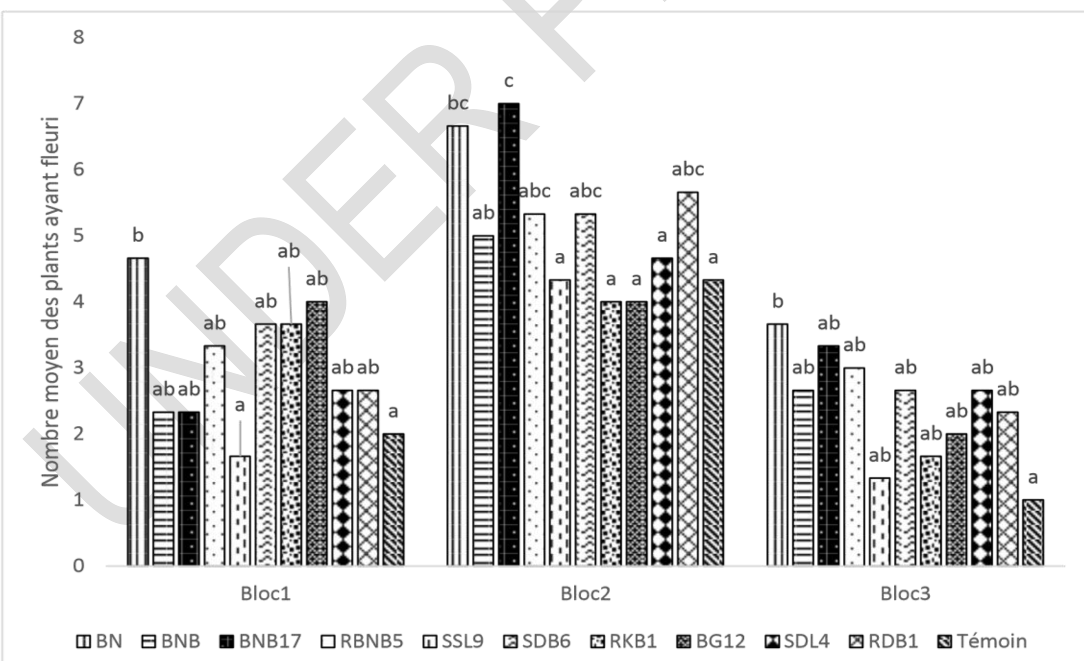


Figure 7: Number of plants de Maize with flowered at 68;75 and 82 DAS.

III.5.2 AVERAGE NUMBER OF PLANTS FLOWERED

Figure 8 show the number of plants flowered. We recorded a highest significant difference (P<0.001) between treatments and the number of plants flowered on every treatment. ANOVA test found a significant difference (p=0.04) on block 2 between average number of plants flowered and the different treatments. The strains RBNB5, SDB6, RDB1, BN, BNB17 and BNB are earlier flowered compared to others treatments. On block 3, we recorded that in all treatments, plants Maize were influenced by the inoculation of MSP compared to control (Figure 9). By these results, strains inoculated with MSP could be classify according to this order: BN> BNB17>RBNB5>BNB ≥SDB6≥ SDL4 >RDB1>BG12>RKB1 SSL9>Control.



NB: Histograms with the same letter are not significantly different at the level of probability considered (P≤ 0.05).

Figure 8: Number of plants flowered within blocks

III.6 INFLUENCE OF MSP ON NUMBER OF COBS OF ZEA MAYS

III.6.1 NUMBER OF PLANTS TAKEN COBS BY TREATMENTS IN EVERY BLOCKS.

Figure 9 show the number of plants with taken the cobs per treatments during three months after sowing (Figure 9). In fact, the appearance of cobs varied from one block to others with high average number of cob recorded (08) on block1, followed by the block 2 (12) and the block 3 (08). Difference on number of cobs was noted between weeks of appearance of cobs and the blocks, followed by these order of classification: block2> block3> block1. For all blocks, the number of control treatments are inferior to others treatments.

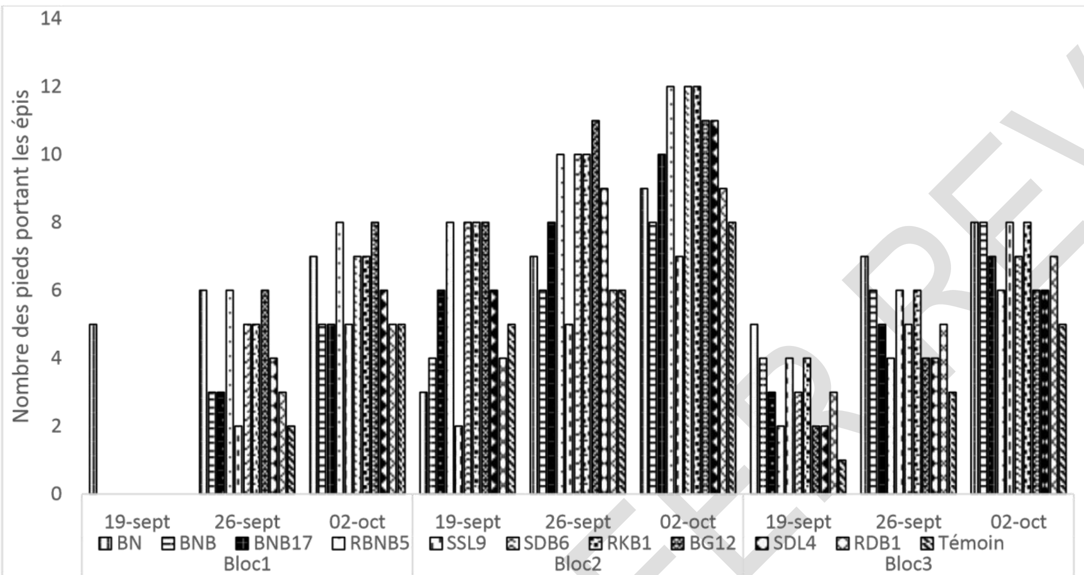


Figure 9: Evolution of number of plants taken cobs per treatments in every blocks.

III.6.2 AVERAGE NUMBER OF COBS PER TREATMENTS ON THE BLOCKS.

Table 4 present the number of cobs per plants for all blocks. Significant differences were recorded among the strains of MSP and the average number of cobs for the block 1 with p-value equal to 0.0032. Good yields were obtained with the treatments BN, RBNB5 and BG12. Treatments SDL4, KB1, SDB6, BG12, RBNB5 and BN have the highest values and are significant different to control treatments. On block 2, significant differences ($p< 0.001$) were observed between treatments and the number of cobs. The strains SSL9, BNB, RDB1 are not significant different to control treatments, compared to the strains BNB17, SDL4, RBNB5, BG12, RKB1 and SDB6 which are statistically different to non- inoculated control. The block 3 which received only rhizobia inoculation treatment reveal a significant difference ($p< 0.001$) between treatments and the number of cobs; Plants maize were affected by the inoculation of MSP compared to control. Followed by these results, the strains of MSP could be classify according to this order: BN>SSL9≥BNB≥RKB1>RDB1≥SDB6≥BNB17>RBNB5≥BG12≥SDL4>Control.

Table 4: Average number of cobs per treatments in blocks.

Strains	**Block 1**	Strains	**Block 2**	Strains	**Block 3**
SSL9	2.33±0.58a	**SSL9**	4.66±0.33a	**Control**	3.0±0.10a
Control	2.33±0.58a	**BNB**	6.0±0.33b	**SDL4**	4.0±0.10b

BNB17	2.66±0.58a	**RDB1**	6.33±0.33b	**BG12**	4.0±0.10b
BNB	2.66±0.58a	**BN**	6.33±0.33b	**RBNB5**	4.0±0.10b
RDB1	2.66±0.58a	**Control**	6.33±0.33b	**BNB17**	5.0±0.10c
SDL4	3.33±0.58ab	**BNB17**	8.0±0.33c	**SDB6**	5.0±0.10c
RKB1	4.0±0.58ab	**SDL4**	8.66±0.33c	**RDB1**	5.0±0.10c
SDB6	4.0±0.58ab	**RBNB5**	10.0±0.33d	**RKB1**	6.0±0.10d
BG12	4.66±0.58bc	**BG12**	10.0±0.33d	**BNB**	6.0±0.10d
RBNB5	4.66±0.58bc	**RKB1**	10.0±0.33d	**SSL9**	6.0±0.10d
BN	6.0±0.58c	**SDB6**	10.0±0.33d	**BN**	6.66±0.10e
Probability	P=0.0032		P=0.000		P=0.000

NB: Values of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤ 0.05) (Test de Duncan).

DISCUSSIONS

Bacterial strains test on *Zea mays* with use of vivianite sediments of soil of Hangloa permit to obtain positive results on growing of plants. Inoculation seeds of Maize by microorganisms with solubilizing phosphorous were significant affected germination. Results showed that germination limit of plants Maize differed according to blocks and strains of MSP. It is most pronounced with the strains BNB17, BNB and RBNB5 on block 3, SDB6, BNB17, BG12, RDB1 on block 2, and RKB1 on block 1 and 3. Similarly, works of Abdourahmane et al. (2020), fertilization effects based of strains mycorrhiza and works of Gnamkoulamba et al. (2018) in inoculated of rice induces that, plants are most vigour during germination compared to the check. Same results were also noted by Wang-Bara et al. (2021) on fertilization of *Sorghum bicolor* by strains fungus (*Rhizophagus irregularis* (50 %), *Scuttellospora gregaria* (10 %), *Gigaspora margarita* (20 %), *Glomus hoi* (20 %)) on germination rate. They founded that germination of plants with strains AMF is most favorable compared to control. However, the majority of strains stimulates the germination of seeds. These results corroborate also with works of Dommergues et al. (1999), founded that some microorganisms on rhizosphere produce vitamin like thiamine, nicotic acid, pantothenic acid, and others, with stimulates germination and growing of plants. It is possible that the stimulation of germination observed with the strains, provides to the production of substances or the increase of concentration of P on soil by these microorganisms.

Ours results showed that the number of leaves were significantly different for all treatments considered by blocks compared to control. Strains of MSP improve on majority the number of leaves during the growing process. According to Huang et al. (2020), mycorrhizal effect have significantly improve leaf number, leaf area and biomass of walnut which depending to the species of AMF. Diameters of plants Maize at 90th days varied for every treatments according to the strains of considered. Significant difference between strains of MSP and diameters of plants were recorded. Considering the blocks, the high values was recorded with the strains: BNB, BG12, BN, BNB17, RBNB5, SDB6, SDL4, SSL9, RDB1. Works of Huang et al. (2020), showed that stem of diameter and roost systems of walnuts were significantly improved with uses of strains AMF.

Phosphate fertilization, inoculation with strains of MSP and use of Mycorrhiza were significantly affected the height of *Zea mays*. These results are in concordance with works of Babana et Antoun (2006) on the effect of rocky phosphates with uses of MSP on wheat and works of Kucey et Leggett (1989) which inoculated plants wheat by *Penicillium bilaji*. Contrary to works of Rock et al. (1996) showing that microorganisms like *Enterobacter sp*., *Pseudomonas sp*., and *Serratia sp* are efficiencies on solubilizing inorganic phosphate on Maize culture. Works of Chabot (1993) on field with Enterobacter and Pseudomonas strains demonstrated that at 60th days after sowing, increasing of plants were suitable on growing (7 to 9

%), precisely on elongation of plants Maize. According to works of Rodriguez and Fraga (1999) on Bacteria and works of Whitelaw, 2000 on Fungus, improvement of growing of plants is suitable by the solubilization of organic phosphorous and inorganic phosphorous of soil. These solubilization could be allotted to the production and to the linearization of organic acids according to Fankem et al. (2006) or phosphatases acids.

Phosphate fertilization and uses of microorganisms with solubilizing phosphorous (MSP) were significantly increase growing of plants Maize (*Zea mays*). For all combined treatments, the growing of plants of Maize increase significantly after applying inoculation process with MSP, Myccorhiza and Natural phosphorous (NP) in the one hand, with MSP and Natural phosphorous (NP) on the other hand. On block 3 non amended, growing plants of Maize are significant proved by inoculation process with strains SSL9. Similar works Traoré et al. (2013) showed positive interactions among mycorrhizal fungus and rhizopheric bacteria on the presence PNT. On poor soils in phosphorous, inoculation with Arbuscular Mycorrhizal Fungus (AMF) reduces the growing of wheat (Graham et Abbott, 2000). Contrary, in our present study, these non-beneficial effect is corrected by application of Natural phosphorous (NP) or by inoculation with microorganisms solubilizing phosphorous (MSP). Also, works of Graham and Timmer (1985) on citrus plants reveals that mycorrhiza promoted P acquisition is correlated to plants status.

CONCLUSION

Objective of this works was to evaluate the impact of strains of MSP on germination period, phenological stages and growing plants Maize (*Zea mays*) in Adamawa region. According to our results strains of MSP improves the germination, growing and number of cobs per plants of *Zea mays* in solubilizing Natural phosphorous (NP). The strains of MSP, BNB7, BNB17, RBNB5, BN and SDB6 were significantly most performants, compared to others strains effect on field. The MSP could be used as biological fertilizers by direct application on soils with Natural phosphorous (NP). Application of MSP was recommended like a guide for increasing of yields, production and improvement of physico-chemical properties of soil.

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