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Methods and Timings of Nitrogen and Phosphorus Fertilizers Application on Emergence and Grain Yield of Maize at Sinana, Southeastern Ethiopia

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Abstract: Soil fertility are paramount important for optimum production of crops and also for subsistence farmers in the Ethiopia highlands. An experiment was conducted on method of placement, time of application of nitrogen (N) and phosphorus (P) fertilizers at Sinana Agricultural Research Center (SARC) during cropping season of *Meher* (August to December), 2006 The objectives were to study methods of N/P and time of N application on emergence and yield of maize. Six methods of fertilizer placements and three timings of fertilizer applications were made by using 75 and 33 kg ha^{-1} N-P. A total of 64 maize seed were planted per plot in rows. Foliar application, side dressing, point application and broadcasting resulted in more than 93% seedling emergence. Whereas, after 12 days of planting the seed, band application and placement with seed resulted in 46% and 99% emergence loss, respectively. Increasing trend of the methods of application on grain yield: Point > Broadcast > Foliar > Band > Side dressing at planting > Placement with the seed. There were increasing trend of grain yield as split and timing N fertilizer application increased. Methods, timings and rate study by soil types and crops are recommended for effective fertilizer utilization due to high cost and less supplies.

Key words: Fertilizer · nitrogen · Maize · Phosphorus · Soil types

INTRODUCTION

Maize is one of those cereals grown in the central and South eastern parts of Ethiopian. In particular Bale and Arsi are generally known to be the cereal belts of Ethiopia. Maize (*Zea mays L.)* is widely grown in the highland agro-ecology of Bale. It is grown as food grain for human being, feeds for livestock's and as a row materials for industrial purposes. Declining soil fertility is among major constraints to agricultural production [1]. The spatial variability in crop yields commonly observed in smallholder farms of sub-Saharan Africa is caused by gradients of declining soil fertility [2]. It affects nutrient use efficiencies, operating mostly on the efficiencies of nutrient capture rather than conversion. The production of maize is mostly affected by low soil fertility and sub optimal use of fertilizers together with irregular rainfall distribution, weeds, disease and cultural management practices [3]. Maintenance of soil fertility at levels which are economically optimal in the long run, under the given productive potential of the land and good climate is important for sustainable agriculture [4]. Productivity decline due to soil nutrient depletion and subsequent land degradation requires the application of external inputs. Increasing fertilizer over control increased grain and straw yields significantly [5]. Most of the developed countries afford a higher level of agricultural inputs, leading to an increasing productivity over time, where as poor nations may be experiencing decline or slowing growth in cereal yields because they lack the financial resources necessary to maintain high levels of agricultural inputs [6]. Phosphorus coated millet seeds enhanced plant development but reduced emergence [7]. Subsistence farmers usually apply N-P fertilizer far bellow the recommended because of unavailability of enough supply and low income earnings as sighted in literature review [3].

A reduction of 23.2% was observed on average grain yield of maize grown in soil with low nitrogen supply, in comparison to that obtained with high nitrogen. In corn, tillering is not important and nitrogen requirement is high during the period of growth such as vegetative phase and silking stage [8]. Modern hybrids uptake nitrogen during silking, contradicting the hypothesis that late N side dressing is not efficient to improve maize grain yield [9]. Small amounts of N in the fertilizer planting encourage absorption of P because N is mobile or become mobile after nitrification [10].

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Nitrogen is generally the most often plant growth limiting nutrient and once applied to the soil it may be immobilized, leached, volatilized or denitrified limiting production of maize in the Ethiopian highlands. Therefore, managing N fertilizer through approporiate methods of placement, timing and rate of application is paramount important for optimum and sustainable maize production in the highlands.). N/Po placement methods and timing of N offers an effective approach to overcome N/ Po deficiency in maize.

The objectives of the experiments were to select methods of nitrogen application on germination and yield of maize and to see the effect of timing of nitrogen fertilizer application using its recommended dose on the grain yield of maize.

MATERIALS AND METHODS

Study Area: The study area is located in the South Eastern part of Ethiopia in Bale Zone of Oromiya National Region State. Then geographical position of Sinana Agricultural Research Center (SARC) is 7°7'N and 39°40°E. The altitude of SARC is 2400m above sea level. The average annual rainfall of SARC was 860mm. The soil type of the experimental site was cambic vertisol with clayey texture: phosphorus was 5.22 ppm, organic carbon was 1.995%, total nitrogen was 0.133%, textural class of the soil was clay with 21% sand, 30% silt and 49% clay and the pH was about 7.3 in the 0-30 cm soil depth, The P, organic carbon and total nitrogen was found in deficient amount in the experimental sites [11].

The experiment was laid out in randomized complete block design with three replications. Only rate of 75-33 kg ha^{-1} N / P was used to see the effect of applied treatments during 2006 "Meher" (August to December) cropping season. The source of N and P were urea and triple supper phosphate (TSP). The variety used was improved maize (ACV3) which is early maturing type. The seeds were planted in rows with spacing between plants 25 cm and between rows 75 cm. The plot size was 3 m by 4 m and the distance between plots is 50 cm and between blocks is 1 m. Seed bed was initially prepared by mould board disc, followed by harrow disk and finally by hand. The six methods of fertilizer placements and three timing of N fertilizer were used as a treatments as separate group experiments as follows: 1. Broadcasting (a means of applying large quantities of nutrients that cannot be conveniently added at planting by mixing the nutrients in the plough layer: P and K usually move by diffusion in water film in the root zone and broadcasted at the time of planting maize), 2. Side dressing,(done by point injector applicator standard knife: not good for immobile nutrient like P and K which are needed early in the season and during the reproductive growth stage 3. Band placement or row placement with the seed usually good in providing rapid start in physiological processes and to have large healthy leaves. Under cool condition N and P are less available to the young plants and band placement will enhance their absorption). 4. Foliar application (this was done by using overhead sprinkler or equipments for spraying pesticides). 5. Placement with a seed (placing maize seed in cotact with urea at the time of planting). 6. Point application (placing fertilizer N and P at planting at equal interval between two maize plants in a raw).

The time of application of the recommended rate of all P was at time of planting but N were applied as follows: 1. all N applied at planting, 2. N split and applied half at planting and half at tillering 3. N split to three and applied 1/3 at planting, 1/3 at tillering and 1/3 at silking and control (0-0 kg ha^{-1} N/P) were treated. Both the methods and timing were conducted separately. A total of 64 maize seed were planted in rows with spacing between maize plant 25 cm between and 75 cm between rows. The design was randomized complete block with three replications. Weed were controlled using 2, 4, D herbicide and all the cultural practices (hoeing the soil at seedling stages to increase aeration for the root) were made for maize during its growth. The data collection was made from the middle two rows of the whole plot at the time of harvesting for grain yield and to avoid border effect. Sources of fertilizer (75 and 33 kg ha^{-1} N-P) were from urea and triple supper phosphate (TSP). After four to six leaf stages 2, 4-D was sprayed at recommended rate (one liter per hectare for maize) to control weed). Finally; data on emergence percent, height to ear and grain yield were collected.

Statistical Analysis: All data collected were analyzed using analysis of variance procedures (ANOVA) using SAS-GLM procedures [12]. The means were separated by the least significant difference (LSD ($\alpha = 0.05$)).

RESULT AND DISCUSSIONS

The result of the experiment showed that maize planted by application of (75-33 kg ha^{-1} N / P fertilizer were indicated in Table 1, Table 2 and Table 3 on emergence of maize seedling, method of placement and timing of N fertilizer application on grain yield of maize at SARC experimental site.

Table1: Methods of nitrogen and phosphorus fertilizer placement on emergence and grain yield of Maize

Treatments	Number of seedling emerged	Emergence (%)	Plant height (cm)	Height to Ear (cm)	Grain yield (kgha-1)
Broad casting	57.7 A	90.2 A	159.57 A	57.77 A	1763.7 BA
Side dressing	57.3 A	89.5 A	157.77 A	48.00 A	1274.8B
Band application	31.7 B	49.5 B	153.77 A	53.77 A	1293.4 B
Point application	57.7 A	90.2 A	159.10 A	60.23 A	1838.3 A
Placement with seed	0.67 C	1.0 C	0.00 B	0.00 B	0.00 C
Foliar application	61.7 A	96.4 A	162.19 A	59.67 A	1444.8 BA
MSE	11.5	11.5	224.62	74.98	77207.55
CV%	26.0	26.0	10.54	17.17	19.42
LSD (0.05)	9.1	9.1	27.266	15.753	505.5

Table 2: Timing nitrogen and phosphorus fertilizer on emergence excluding control on maize

Treatments (kg ha^{-1})	Plant height(cm)	Height to ear (cm)	Grain yield (kg ha^{-1})
75/ 33, All at once	143.4 A	48.2 A	1075 A
75/ 33, 1/2 at planting & ½ at tillering	146.6 A	40.5 A	1445.5 A
75/33 each 1/3 at planting, tillering & booting	154.8 A	48.3 A	1227.2 A
Mean	148.2	45.7	1249.23
CV	5.89	22.6	14.4
LSD (0.05)	19.806	23.44	407.2

P= 33 kg/ha, all applied at planting & N =41 kg/ha split and timed

Table 3: Effect of application of nitrogen and phosphorus on emergence after germination of maize using six methods of applications and the emergence date were in a range of 12 to 18 days after planting

	1st emergence day		2nd emergence day		3rd emergence day		4th emergence day		5th emergence day		6th emergence day	
	M	A	M	A	M	A	M	A	M	A	M	A
Broad casting	41.7 A	47.0 A	51.0 A	51.0 A	53.3 A	53.3 A	57.7 A	58.0 A	59.0 A	60.0 A	60.3 A	60.3 A
Side dressing	44.0 A	51.0 A	53.3 A	55.3 A	55.7 A	55.7 A	57.3 A	57.7 A	58.7 A	59.7 A	62.0 A	62.0 A
Band application	14.3 B	18.0 B	23.0 B	27.7 B	29.0 B	29.0 B	31.7 B	32.0 B	35.3 B	38.3 B	41.3 B	41.3 B
Point application	44.0 A	50.0 A	55.0 A	56.0 A	56.3 A	56.3 A	57.7 A	58.0 A	58.3 A	60.7 B	60.7 A	60.3 A
Placement with seed	0.33 C	0.33 C	0.67 C	0.67 C	0.67 C	0.67 C	0.67 C	0.67 C	0.67 C	0.67 C	0.67 C	0.67 C
Fo liar application	43.3 A	47.3 A	56.7 A	57.3 A	58.7 A	58.7 A	61.7 A	62.3 A	62.3 A	64.0 A	64 A	64 A
MSE	50	20.5	12.3	10.7	10.6	10.6	11.5	11.2	11	11.5	11.5	11.5
CV (%)	22	52.8	24.1	19.6	20.1	20.1	26	25	28.8	27	30.56	30.6
LSD(0.05)	12.9	13.2	8.9	8.1	8.2	9.3	9.1	9.12	9.7	9.4	10.0	10.1

Where CV = coefficient of variation, MSE = mean sum of square error, LSD = least significant difference, A, B and C used to show significant levels of each method on emergence; numbers in the column heads are emergence dates M= morning and A= after noon

The Six Methods on Emergence of Maize at Sarc Trial Site: As the summery (Table 1) and detail (Table 3) of ANOVA of methods of application of nitrogen and phosphorus fertilizers were shown. Both germination and grain yield were significantly differed for the applied methods. Maize emergence was started after 12 days and continued until 17 days after planting the seed. Among 64 maize seed planted in rows per plot (Table 3) 100% germination and seed ling emergence was resulted under foliar application methods of N/Po was observed. Where followed by Side dressing (97%), Broad casting and point application (each 94.2%) and are not statistically different from foliar application. Band application that is placement of the maize seed in rows with N/Po reduces the yield by 36% as compared with foliar application (100%). The lowest seed emergence (1%) was observed when maize seed was placed on N/P0 that is 99% emergence loss. Similarly, the finding of [7] indicated that nitrogen and phosphorus placement with maize seed resulted in risk of seedling injury, especially under drought conditions. Also contradicting these techniques, few subsistence farmers of Bale highlands have different methods of application of fertilizers when planting cereals, they place it by soaking less than

10 kg N/P_0 per 100 kg cereal crops seed for overnight before planting the seed in the following day. They said we harvest better yield if planting was made during rainy time (personal interview and observation).

With foliar application of fertilizer gave 100% germination and placement with seed the least emerged, only 1%. The grain yield increase increasing order of the methods The six methods of N/P0 applications when compared with one another on emergence and yield of wheat in the order of increasing tendancy as follows: Foliar application > Side dressing > point application > broadcasting > band application > placement with seed. Band or row placed placement with seed of N/P0 fertilizer declined the population density of maize plant by 46% and 99%; respectively. From this result therefore; it is possible to conclude that placement of maize seed in contact with nitrogen and phosphorus fertilizer resulted in germination loss and no emergence of maize seedling. This might be attributed to failure of the seed to germination or sever injury to the germinated seedling due to fertilizer toxicity resulting in necrosis of the germinated seed. Banded urea can result in toxicity to maize germination and growth, due to accumulation of NH_3 and NO_2^-as a result of urea hydrolysis. In the field, maize germination decreased with banded urea and increased with banded TSP at Day 10 after sowing, but no difference was found at Day 20. [13].

Effect of the Six Methods on Grain Yield of Maize at Sarc Trial Site: As is summarized in the Table 1, Table 2 and Table 3 ANOVA of methods of application of phosphorus and nitrogen fertilizer showed significant difference. Optimum grain yield of ACV3 maize 1838.3 kg ha^{-1} were obtained during the "Meher" cropping seasons of 2006. Similar grain yield of maize ACV3 were obtained when The highest grain yield of maize was obtained when 75 /33 kg ha^{-1} N/P of nitrogen was applied by point application followed by broadcasting and foliar application methods (Table 1, means with the same latter,do not differ significantly from each other). Broad casting, Side dressing, band application and foliar application were not significantly different from each other. No maize grain yield was harvested when maize seed was placed on nitrogen fertilizer at the time of planting. In order of increasing grain yield the six methods are Point application > Broad casting > Foliar application > Band application > Side dressing at planting > placement with the seed (almost no seedling emerged).

From the experimental result it was observed that maize seed planted in contact with N and P fertilizer totally were not emerged. The farmers practicing such methods are like those who exercised fallow. Similarly, in areas where supply of N fertilizers is a constraint farmers soak their seed in less than 10 kg of urea per 100kg of seed before planting in the following day (personal interview). After this treatment, subsistence farmers of Bale said, with effective precipitation there will be good yield and in the absence of it during planting time there will be loss of their production.

Time of N/P_0 Application: Timing of fertilizer placement was under taken as separate group of experiment at Sinana on station trial site using maize seed. The summery of ANOVA of time of N application was shown (Table 2.). All the three timing of nitrogen fertilizer application didn't result in significant maize grain yield. Although there was no significance difference due to applied treatments between split N and all P there were increasing trend of grain yield as splitting of N fertilizer was increased. Splitting N in to two and applying half at planting and half at tillering gave a yield advantage of 249.7 kg ha^{-1} over applying all N at planting. And splitting in to three and applying 1/3 of N at planting, 1/3 of N at tillering and 1/3 at booting gave a yield advantage of 266.1 kg ha^{-1} over supplying all at once. A similar report on medium to high P soil, the time and methods are less important and proportionately larger applications of P every 2 to 4 years may be recommended [10]. Where as, N application is made when the peak time of crop N requirement occurs and producers usually apply nutrients at time that will maximize recovery by the crop and reduce the potential for environmental problems [10].

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