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Effect of Different Nutrient Management Practices and Zinc Fertilization on Various Growth and Development Stages of Maize (*Zea mays L.*) under Dryland Condition

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A B S T R A C T

Field studies were carried out during the growing season 2015-16 at Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) to study "Effect of different nutrient management practices and zinc fertilization on various growth and development stages of maize (*Zea mays* L) under dryland condition". The treatments were laid out in a randomized block design (FRBD) with three replications. The experimental results indicate that application of RDF 125% along with $ZnSO_4$ @ 20 kg ha^{-1} procured the best result in maximum growth parameters and sometime found to be at par with the application of RDF 125% along with $ZnSO_4$ 40 kg ha^{-1}.

Introduction

Maize (*Zea mays* L.), is also known as corn, Makka or Makki which belongs to family Poaceae is the world's 3rd most important cereal crop after rice and wheat. Maize (*Zea mays* L.) is produced largely worldwide than any other cereal grain and it has a pivotal role in increasing the income of both substance and commercial farmers. India ranks fifth in the area and third in production and productivity among cereal crops (Rao *et al.*2014). In India, maize is being cultivated in an area of 8.78 million ha with a production of 24 million t and average productivity of 2.5 t ha^{-1} the fifth largest producer in the world contributing 3 percent of the global production (Anonymous, 2014). But when it comes to productivity; the state of Maharashtra has far low productivity (4.34 t ha^{-1}) than the global average. Being versatile crop maize can be grown virtually everywhere hence it is a good choice for dryland area.

In developing countries of Asia and Africa; maize is providing much-needed nutrition to otherwise hungry people. It is estimated that several million people in developing countries derive their protein and calorie (11.1 g and 342 kcal day^{-1}) requirement from maize (Gopalan *et al.*, 1999) thus, maize grain accounts for about 15 to 56 percent of the total daily diet of people in 25 developing countries.

Maize is capable of producing very high amount of biomass and yield but with the only condition that it requires a plentiful supply of mineral nutrition. To prevent the soil from getting exhausted especially in dryland condition; it is very much essential to maintain regular and balanced fertilizer application. When it comes to fertilizer application; micronutrients especially zinc has never been considered seriously due to the uncertainty of water and economically weaker condition of the farmer. Physiologically maize is very sensitive to zinc nutrition and its growth and development are often ostracized due to its deficiency. Indian soi, in general, is deficient in zinc and requires frequent zinc fertilization. Due to all these facts stated above; it was necessary to conduct an experiment in dryland vertisols of Maharashtra to evaluate the effect of zinc fertilization on growth and development of maize hence the investigation entitled "Effect of various nutrient management practices and enriched zinc fertilization on various growth and development stages of maize (*Zea mays* L.) under dryland condition" was carried out.

Materials and Methods

The experiment was carried out in the plot No. 66 at Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during Kharif season of 2015- 2016. The topography of soil was fairly leveled with 2 percent grade, clayey medium dark vertisols in nature and moderately alkaline (pH 8.6). The organic carbon of the soil was 0.51 g kg^{-1}. The chemical analysis of soil indicated various available mineral nutrient contents as given in Table 1. The experiment was arranged in a randomized block design with three replications, and the plot size was 4.8 m x 6 m. Sowing of maize was taken on 23-06-2015. The field was irrigated immediately after sowing for assured seed germination. Seeds were dibbled at 3-5 cm depth @ two seeds per hill. Sowing was done at the spacing of 60 cm between rows and 20 cm with in rows with a seed rate of 20 kg ha^{-1}. Maize variety "PKV Shatak" was selected as a test variety with a duration of 85-95 days and yield potential of 55-60 q ha^{-1}. The experiment had 8 treatments viz., T_1- RDF 100 %, T_2-RDF 125%, T_3- RDF 75% + FYM 5 ha^{-1}, T_4- RDF 100% + $ZnSO_4$ 20 kg ha $^{-1}$, T_5- RDF 100% + $ZnSO_4$ 40 kg ha^{-1}, T_6- RDF 125% + $ZnSO_4$ 20 kg ha^{-1}, T_7- RDF 125% + $ZnSO_4$ 40 kg ha^{-1} and T_8- RDF 100%+ Seed priming with $ZnSO_4$ 1% w/v. The land preparation was similar for all the treatments. Eight plants were selected in the early stages from each plot at random order. Each plant marked with a small plastic white colored ring and with wooden peg nearby for demarcation. The same eight plants were observed at various stages of crop growth up to the harvesting stage for biometric observations. These eight plants were harvested separately for post-harvest observations.

Results and Discussion

The results obtained from the present investigation have been presented under the following heading

Growth characters

Plant height (cm)

Data derived from the experiment showed that the zinc application had a significant effect on the plant height of maize during 40 DAS and 60 DAS. The comparison of treatment means revealed that zinc application 40 kg ha^{-1} along with increased does of fertilizer (T_7) consistently maintained significantly tallest plant except 60 and 80 DAS. At grand growth stage (60 DAS) the maximum plant height (180.2 cm) was noticed with addition of zinc 20 kg ha^{-1} along with increased fertilizer dose (T_6) which was comparable with addition of 20 kg $ZnSO_4$ along with RDF as well as addition of 40 kg $ZnSO_4$ with 125% RDF and 100% RDF (T_4, T_7 and T_5). The recommended dose of fertilizer produced shorter plants compared to the rest of the treatments. Seed priming with $ZnSO_4$ improved plant height marginally. More or less similar results were observed at the stage of 40 DAS. Increase in plant height with the addition of $ZnSO_4$ either 20/40 kg ha^{-1} in additions to the recommended fertilizer dose increase in plant height may be due to the availability of more nitrogen and internodal distance due to zinc application. These results were matching with the findings of Mohseni and Haddadi (2014) (Table 2).

Functional leaves plant^{-1}

Functional leaves are the important parameter in understanding photosynthesis, light interception, water and nutrient use, crop growth and yield. It was observed that the periodic number of functional leaves increased progressively up to physiological maturity but the magnitude of increase was more than double from 60 to 80 DAS, irrespective of the treatments. Results derived from the experiment indicated that the zinc application had a significant effect on the number of functional leaves of maize during the entire growth of plant except at 20 DAS and at harvest.

At 20 DAS, various nutrient management practices did not cause any significant variation in a number of functional leaves. At 40 DAS application of $ZnSO_4$@40 kg ha^{-1} (T_7) was responsible for producing a maximum number of leaves which was comparable with 20 kg $ZnSO_4$ along with 125% RDF & 100% RDF as well as with increased RDF (T_6, T_4 and T_2). Being heavy feeder, maize responded to high fertility which confirms the increased no. of leaves at 125 % RDF (T_2). More or less similar observations were noticed at 80 DAS. At 60 DAS, maximum production of leaves was observed with 100% RDF + 40 kg $ZnSO_4$ which was at par with the application of 20 and 40 kg ha^{-1} of $ZnSO_4$ along with 125% RDF (T_6 and T_7). Nutrient management did not show any significant variation in the production of functional leaves at harvest. Increased number of leaves with the application of zinc maybe du to increased mobility of nitrogen. Seed priming with $ZnSO_4$ along with RDF increased the number of leaves marginally but not reached to the level of significance which is different than what has been observed by Fageria *et al.*, (2006).

Leaf area plant^{-1} (dm^2)

Leaf area estimate is an important parameter in understanding photosynthesis, light interception, water and nutrient use, crop growth and yield. The experiment indicated that the leaf area increased progressively during the vegetative stage and reached tothe maximum during physiological maturity (80 DAS), thereafter it declined sharply towards harvest maturity due to leaf fall owing to their senescence. Experimental data revealed that zinc application had a significant effect on leaf area per plant across the crop growing period.

At 20 DAS, maximum leaf area (0.0178 dm^2) was observed at RDF125% along with $ZnSO_4$@ 40 kg ha^{-1} (T_7) which was at par with application of $ZnSO_4$@ 20 kg ha^{-1} along with 125% RDF and with application of 40 kg ha^{-1} of $ZnSO_4$ along with 100% RDF (T_6 and T_5) and found significantly superior than alone 100% recommended dose of fertilizer. More or less similar results were observed at 60 DAS.

At 40 DAS, application of $ZnSO_4$@ 20 kg

ha^{-1} along with increased RDF (T_6) was responsible for producing maximum leaf area which was at par with 40 kg $ZnSO_4$ along with increased fertilizer dose, 40 kg $ZnSO_4$ + 100% RDF (T_7 and T_5) and significantly superior over rest of the treatments. Being heavy feeder crop, maize responded to high fertility which confirms the increase leaf area at 125 % RDF (T_2). Seed priming with 1% $ZnSO_4$ along with RDF produced significantly more leaf area. More or less similar observations were noticed at 80 DAS and at harvest. Increased leaf area with the application of zinc may be due to the increase in leaf expansion (length and breadth), high rate of cell division and cell enlargement, rapid growth and there by improved quality of vegetative growth. Reduction in RDF resulted in a reduction of leaf area. This indicates that the nutrient requirement could not be compensated through FYM.

Leaf area index

Leaf area index (LAI) is a measure of leafiness per unit ground area and denotes the extent of the photosynthetic machinery. It is the most important indicator of the size of the assimilatory system in maize to maximize harvest of the incident solar radiation. The experimental data indicated that there was a considerable increase in leaf area index from 20 DAS up to 80 DAS to a maximum extent of 5.45 then it showed declining trend at harvest due to increasing aging of leaves, shading, and competition between plants for light and other resources. At 20 DAS, maximum leaf area index (0.148) was observed at RDF125 % along with $ZnSO_4$40 kg ha^{-1}(T_7) which was comparable with the application of $ZnSO_4$ 40 kg ha^{-1} along with 100% RDF, application of 20 kg ha^{-1} of $ZnSO_4$ + 125% RDF, application of $ZnSO_4$ 20 kg ha^{-1} + 100% RDF (T_5, T_6 and T_4) and found significantly superior than alone 100% recommended dose of fertilizer. More or less similar results were observed at 60 DAS. At 40 DAS, application of $ZnSO_4$@ 20 kg ha^{-1}along with increased RDF (T_6) was responsible for producing maximum leaf area index, which was at par with 40 kg $ZnSO_4$ along with increased fertilizer dose and with 100% RDF (T_7 and T_5) and found significantly superior over rest of the treatments

Being heavy feeder, maize responded to high fertility, which confirms the increase in leaf area index at 125% RDF (T_2). Seed priming with 1%$ZnSO_4$ along with RDF produced significantly more leaf area index. More or less similar observations were noticed at 80 DAS and at harvest. Reduction in fertilizer dose resulted in less leaf area index as the nutrients could not be compensated by FYM.
Increase in leaf area index by zinc application might be due to an increase in tryptophan amino acid and indole acetic acid hormone, which are two main factors of leaf area expansion in maize crop. These findings were earlier confirmed by Seifi Nadergholi *et al.*, (2011).

Dry matter accumulation(g $plant^{-1}$)

The study revealed that there was a gradual increase in dry matter production of the crop from knee height stage up to maturity. Results showed that the dry matter accumulation increased from a mean of 5.28 g $plant^{-1}$ at 20 DAS up to 129.14 g $plant^{-1}$ at harvest. A gradual increase in dry matter accumulation was observed at 40, 60, 80 DAS up to harvest. At 20 DAS, maximum dry matter accumulation (5.92 g $plant^{-1}$) was observed with the application of RDF 125% along with $ZnSO_4$ @ 20 kg ha^{-1} (T_6) which was at par with application of RDF 125% along with $ZnSO_4$ 40 kg ha^{-1}(T_7), application of RDF 100% along with $ZnSO_4$@ 40 kg ha^{-1} (T_5) and was significantly superior over the rest of the treatments. Seed priming was found effective to increase dry matter.

At 40 DAS application of $ZnSO_4$ 20 kg ha^{-1} along with 125% RDF produce maximum dry matter accumulation, which was comparable with 40 kg $ZnSO_4$along with 125% & 100% RDF as well as with 20 kg zinc with 100% RDF, and found significantly superior over rest of the treatments. Reduction in dry matter was observed with the reduced fertilizer dose. Integration of nutrient through FYM could not compensate for the dry matter accumulation compared to RDF indicating no beneficial effect of it on the growth of the crop. Seed priming with $ZnSO_4$ 1% was found beneficial to increase the dry matter of maize. This trend was noticed at subsequent growth stages of maize. Higher dry matter production with the application of zinc could be attributed to enhanced plant height, leaf area index and photosynthates accumulation, thereby improving the plant vigor due to the source-sink relationship. Addition of zinc along with RDF may be responsible for the availability of nitrogen which reflected into increased growth parameters, which ultimately increased the dry matter accumulation. These findings are in conformity with those of Pokharel *et al.*, (2009), Tetarwal *et al.*, (2011) and Ravi *et al.*, (2012).

Development characters

Days of 50% tasseling and 50% silking

The experimental data indicated that the maize requires 45 days for 50% flowering and 51 days for silking. Across the treatment, it was observed that the application of zinc delayed the 50 % flowering and 50% silking. In general, it was noticed that reduced fertilizer dose reduced the days required for 50% flowering and silking by 2- 3 days. As the levels of zinc increased, 50% flowering was delayed. The abundant supply of fertilizers to the crop will promote vegetative growth form maize, there by delaying flowering compared to the crop supplied with less or without fertilizers which attains flowering earlier (Table 3).

Table.1 Various available mineral nutrient content in the soil

Mineral Nutrient	Concentration in soil	Procedure used in the analysis
Nitrogen	205.3 kg ha^{-1}	Alkaline permagnate method (Subbiah and Asija,1956)
Phosphorus	16.88 kg ha^{-1}	Olsen's method (Olsen *et al*., 1954)
Potassium	367.22kg ha^{-1}	Neutral normal ammonium acetate using Flame Photometer. (Jackson, 1973)
Zinc	0.59 mg kg^{-1}	Atomic absorption Spectrophotometer (Lindsay and Norvell, 1978)

Table.2 Plant height (cm), number of functional leaves plant^{-1} and dry matter accumulation (g plant^{-1}) of maize as influenced by various nutrient management practices and zinc application

	Growth characters														
	Plant height (cm)					No. of functional leaves plant^{-1}					Dry matter accumulation (g plant^{-1})				
	Day after sowing				AH*	Day after sowing				AH*	Day after sowing				AH*
	20	40	60	80		20	40	60	80		20	40	60	80	
T1 (RDF 100%)	13.56	46.06	153.13	177.00	182.53	6.10	7.00	7.20	12.56	9.93	4.65	25.40	53.90	85.00	110.86
T2(RDF 125%)	16.03	52.66	173.03	184.06	189.60	6.86	7.80	7.53	13.46	12.20	4.95	27.96	54.73	87.33	117.50
T3(RDF 75%+FYM 5 t ha-1)	14.5	44.33	159.16	165.16	170.93	6.80	7.23	7.33	12.10	10.73	4.39	22.80	44.13	71.50	102.76
T4(RDF100%+$ZnSO_4$ 20kg ha^{-1})	13.23	55.83	179.00	188.50	191.93	7.33	8.10	8.03	15.80	11.46	5.29	30.26	57.00	94.33	137.80
T5(RDF100%+$ZnSO_4$ 40 kg ha^{-1})	15.00	61.33	170.50	178.20	185.93	6.46	7.76	8.53	16.46	13.06	5.89	29.00	53.16	93.66	140.00
T6(RDF125%+$ZnSO_4$ 20kg ha^{-1})	15.63	65.66	180.20	185.50	191.33	6.60	8.26	8.26	15.73	12.46	5.92	31.16	61.56	103.33	144.00
T7(RDF125%+$ZnSO_4$ 40kg ha^{-1})	16.13	66.33	177.53	182.60	193.13	6.86	8.43	8.36	16.66	12.46	5.89	30.80	59.50	102.00	147.37
T8(RDF100%+seed priming WithZnSO4 1%)	14.10	53.73	159.66	176.06	182.33	6.40	7.80	7.70	15.90	12.26	5.29	28.00	58.40	99.06	132.86
SE(m) ±	0.74	2.10	3.51	6.23	6.44	0.23	0.21	0.15	0.34	1.41	0.18	0.80	1.06	1.42	5.36
CD (P= 0.05)	NS	6.37	10.64	NS	NS	NS	0.64	0.46	1.04	NS	0.54	2.43	3.24	4.31	16.27
GM	14.77	55.75	169.02	179.64	185.97	6.67	7.80	7.87	14.84	12.1	5.28	28.53	55.3	92.02	129.14

(AH*- At harvest stage)

Table.3 Leaf area (dm^2) $plant^{-1}$, Leaf Area Index and developmental stages of maize as influenced by various nutrient management practices and zinc application

	Growth characters											
	Leaf area (dm^2) $plant^{-1}$					Leaf Area Index					Developmental stage (in days)	
	Day after sowing				AH*	Day after sowing				AH*	Days to 50% tasseling	Days to 50% silking.
	20	40	60	80		20	40	60	80			
T1 (RDF 100%)	0.0118	0.0824	0.3613	0.6109	0.3026	0.09	0.68	3.00	5.08	2.50	45	51
T2(RDF 125%)	0.0141	0.0870	0.3804	0.6210	0.3458	0.11	0.72	3.16	5.17	2.88	45	50
T3(RDF 75%+FYM 5 t ha^{-1})	0.0101	0.0795	0.3481	0.5853	0.2847	0.08	0.66	2.89	4.87	2.36	44	50
T4(RDF100%+$ZnSO_4$ 20kg ha^{-1})	0.0150	0.0954	0.4485	0.6767	0.3663	0.12	0.78	3.73	5.63	3.05	46	52
T5(RDF100%+$ZnSO_4$ 40 kg ha^{-1})	0.0156	0.0981	0.4667	0.6920	0.3762	0.12	0.81	3.88	5.76	3.13	47	52
T6(RDF125%+$ZnSO_4$ 20kg ha^{-1})	0.0150	0.0994	0.4678	0.7078	0.3897	0.12	0.82	3.89	5.89	3.24	46	52
T7(RDF125%+$ZnSO_4$ 40kg ha^{-1})	0.0178	0.0985	0.4779	0.7034	0.3886	0.14	0.82	3.97	5.85	3.23	45	51
T8(RDF100%+seed priming With $ZnSO_4$ 1%)	0.0146	0.0923	0.4629	0.6411	0.3183	0.10	0.76	3.85	5.30	2.64	46	51
SE(m) ±	0.0007	0.001	0.009	0.008	0.005	0.005	0.01	0.01	0.07	0.04	0.67	0.73
CD (P= 0.05)	0.0024	0.003	0.0027	0.0026	0.0016	0.01	0.03	0.23	0.21	0.14	NS	NS
GM	0.0142	0.0916	0.4267	0.6547	0.0034	0.11	0.76	3.55	5.45	2.88	45	51

(AH*- At harvest stage)

On the basis of the results attained, the following conclusions of noteworthy and utility can be drawn:

Application of zinc fertilizer plays a significant role in the growth and development of maize plants.

Application of Zinc sulfate at the rate of 20 kg ha^{-1} along with the slightly increased rate of the recommended dose of fertilizer has been found to be significant over all other nutrient management practices.

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