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EFFECT OF MAGNESIUM ON GROWTH, YIELD AND QUALITY OF BANANA

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ABSTRACT

The field experiment entitled, "Effect of magnesium on growth, yield, soil properties and nutrient uptake by banana" was conducted at Banana Research Station (MPKV), Jalgaon during *mrug bag* season 2023-24 with an objective to study the effect of magnesium on growth, yield and quality parameters of banana Cv. Grand naine. Treatments were composed of T_1: GRDF (150:60:150 g N: P_2O_5:K_2O +10 kg FYM per plant), T_2: GRDF + 10 g plant^{-1} Magnesium Sulphate, $T_{3:}$ GRDF + 20 g plant^{-1} Magnesium Sulphate, $T_{4:}$ GRDF + 30 g plant^{-1} Magnesium Sulphate, T_5: GRDF +40 g plant^{-1} Magnesium Sulphate, T_6 : GRDF +50 g plant^{-1} Magnesium Sulphate. The treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) recorded higher pseudostem girth (77.2 cm), number of functional leaves (13.2), total leaf area (18.1 m^2) and leaf area index (8.04), number of fingers per bunch (186), banana bunch weight (27.4 kg) and banana yield (121.9 t ha^{-1}). Among the quality parameters of banana, total sugar content in banana fruit was significantly influenced due to application of magnesium for banana, however, the TSS and acidity showed non-significant results due to application of magnesium for banana. The treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) recorded significantly higher monetary returns of Rs. 9,74,836 /-, net profit of Rs. 6,24,125 /- and B:C ratio 2.78.

Key words: Banana, growth parameters, yield parameters, quality parameters, magnesium

Introduction

Banana botanically, *Musa Sp.* is also referred to as the tree of paradise. India, with an annual production of 33.06 million tonnes from 9,24,000 ha area is the largest producer of banana. It contributes 26.47 % of the global production and about 37% of total fruit crop production in the country (FAO, 2021). Among the Indian states, Maharashtra contributes maximum area of about 90,000 ha for banana cultivation and accounts for 25% of the total banana production.

The best-known physiological role of magnesium is in harvesting solar energy by occupying the central position in the chlorophyll structure, as a cofactor and allosteric modulator for more than 300 enzymes (including carboxylases, phosphatases, kinases, RNA polymerases, and ATPases) and in chelation to nucleotidyl phosphate forms (Hawkesford *et al.*, 2012). Magnesium occupies the central position of the chlorophyll structure and between 10 and 20% of the total Mg can be bound to that pigment (Wilkinson *et al.*,1990). In banana Mg deficiency shows symptoms like marginal yellowing on older leaves, changes in phyllotaxy, purple mottling of petioles and separation of leaf sheaths from the pseudostem, leaves turn yellow in a broad marginal band, which consequently also reduces photosynthesis and yield potential. Also reduced yield caused by low Mg supply is proportional to reduced growth in plant parts of banana (Turner and Barkus, 1980). When plants experience a magnesium deficit, the mobile element magnesium is typically remobilized and distributed from the older to younger leaves (Mengel and Kirkby, 1987; Marschner, 2012). As a result, immature leaves in plants could not experience magnesium deficiency, which has an impact on the transport of carbohydrates. The banana plant needs a lot of magnesium, and because of its high biomass and quick development, deficiencies in this element are frequently seen. When a banana plant is deficient in magnesium, its new leaf will fully expand and grow normally if the mineral is remobilized and distributed to the young leaves. The mobile element magnesium is usually remobilized and transferred from the older to the younger leaves in plants that suffer from a magnesium deficiency (Mengel and Kirkby, 1987; Marschner, 2012).

The scientific information on effect of magnesium on growth, yield, soil properties and nutrient uptake by banana is very scanty. Considering the importance and absence of information on these aspects of the soil, the present investigation was carried out to study the effect of magnesium on growth, yield and quality parameters of banana.

Materials abd Methods

The field experiment was conducted at Banana Research Station (MPKV), Jalgaon during *mrug bag* season 2023-24 with an objective to study the effect of magnesium on growth, yield and quality parameters of banana Cv. Grand naine. The experiment was laid out in randomized block design with six treatments replicated four times. Treatments were composed of T_1 : GRDF (150:60:150 g $N:P_2O_5:K_2O$ +10 kg FYM per plant), T_2 : GRDF + 10 g plant^{-1} Magnesium Sulphate, T_3 : GRDF + 20 g plant^{-1} Magnesium Sulphate, T_4 : GRDF + 30 g plant^{-1} Magnesium Sulphate, T_5 : GRDF +40 g plant^{-1} Magnesium Sulphate, T_6 : GRDF +50 g plant^{-1} Magnesium Sulphate. General recommended dose of fertilizers 150:60:150 g $N:P_2O_5:K_2O$ per plant through fertigation (N and K_2O in 44 splits and P_2O_5 in 16 splits at weekly interval) +10 kg FYM per plant was applied to all the treatments. Magnesium sulphate ($MgSO_4$) was applied as per treatment in 15 splits from 7th to 21st week through fertigation. The soil of the experimental field was medium black, having pH 8.12, electrical conductivity (EC) 0.29 dS m^{-1}, moderate in organic carbon content (4.90 g kg^{-1}), low in available nitrogen (205 kg ha^{-1}), moderate in available phosphorus (19.25 kg ha^{-1}) and very high in available potassium (712 kg ha^{-1}) and having exchangeable magnesium 16.45 cmol (p+) kg^{-1}.

Five plants from each plot were selected randomly by taking due care in each plot and tagged permanently for recording biometric observations. The biometric observations *viz.*, number of functional leaves, pseudostem height, pseudostem girth and leaf area were recorded at shooting stage (Barker, 1969). The leaf area (m^2) for fully opened third leaf from the top was estimated according to Murray (1961). Leaf area index (LAI) was estimated as the leaf area of a plant divided by land area covered (Watson, 1958). The total sugars was determined by using Fehling reagent as per the method suggested by Lane and Eynon (1923). The total soluble solids were determined by using hand refractometer and the results expressed as percentage at 21^{0}C (A.O.A.C.,1990). Titrable acidity was determined by diluting 1 g homogenized banana pulp with distilled water and titrated with 0.1 *N* NaOH using few drops of 1 % phenolphthalein solution as indicator (A.O.A.C., 1990).

Results and Discussion

Growth parameters of banana

Pseudostem height

The height of banana pseudostem increased gradually with the increase in magnesium levels (Table 1). The treatment of GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) recorded significantly higher pseudostem height 2.53 m, which was at par with GRDF + 40 g plant^{-1} $MgSO_4$ (T_5) and GRDF + 30 g plant^{-1} $MgSO_4$ (T_4). The increase in plant height could be attributed to the increase in the uptake of nutrients, more specifically nitrogen and magnesium. The absorbed nitrogen ultimately led to the formation of complex nitrogenous substances like proteins and amino acids to build up new tissues (Childers, 1966). Significantly lower pseudostem height (2.33 m) was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2).

Pseudostem girth

The treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) recorded significantly higher pseudostem girth 77.2 cm (Table 1) indicating rapid vegetative growth at this fertility level, which was at par with GRDF + 40 g plant^{-1} $MgSO_4$ (T_5), GRDF + 50 g plant^{-1} $MgSO_4$ (T_6), and GRDF + 20 g plant^{-1} $MgSO_4$ (T_3). Significantly lower pseudostem girth (72.8 cm) was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2).

Number of functional leaves

Significantly higher number of functional leaves 13.2, were recorded in the treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) and GRDF + 40 g plant^{-1} $MgSO_4$ (T_5) (Table 1). Leaf production in banana is related to increased rate of plant growth (Barker and Steward, 1962; Sathyanarayana, 1985). Application of magnesium would have increased the chlorophyll content and photosynthetic rate of the plants which in turn can enhance the rate of leaf production. These treatments were at par with, GRDF

Table 1: Growth parameters of banana at shooting stage as influenced by graded levels of magnesium

Treatments	Pseudo-stem height (cm)	Pseudo stem girth (cm)	No. of functi-onal leaves	Total leaf area (m^2)	Leaf area index
1. GRDF	2.33^{d}	72.8^{c}	11.8^{b}	15.5^{b}	6.89^{c}
2. GRDF + 10 g plant^{-1} $MgSO_4$	2.38^{cd}	74.5^{b}	12.1^{b}	16.0^{b}	7.13^{c}
3. GRDF + 20 g plant^{-1} $MgSO_4$	2.43^{bc}	75.8^{ab}	12.9^{a}	17.3^{a}	7.71^{b}
4. GRDF + 30 g plant^{-1} $MgSO_4$	2.48^{ab}	77.2^{a}	13.2^{a}	18.1^{a}	8.04^{a}
5. GRDF + 40 g plant^{-1} $MgSO_4$	2.52^{a}	76.7^{a}	13.2^{a}	17.9^{a}	7.94^{ab}
6. GRDF + 50 g plant^{-1} $MgSO_4$	2.53^{a}	76.2^{ab}	12.9^{a}	17.3^{a}	7.68^{b}
SEm +	0.016	0.63	0.17	0.24	0.11
CD at 5 %	0.049	4.90	0.50	0.72	0.32

+ 50 g plant^{-1} $MgSO_4$ (T_6) and GRDF + 20 g plant^{-1} $MgSO_4$ (T_3). Significantly lower number of functional leaves 11.8, were observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2). Turner and Barker (1983) also reported that low Mg supply reduced the number of live leaves present on the plants.

Total leaf area

Leaf area is closely linked to dry matter accumulation and has therefore been used to estimate the photosynthetic capacity and to predict the performance of a crop (Turner, 1980; Stover and Simmonds, 1987). The total leaf area increased with the increase in magnesium level (Table 1). The treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) recorded significantly higher total leaf area 18.1 m^2, which was at par with GRDF + 40 g plant^{-1} $MgSO_4$ (T_5), GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) and GRDF + 20 g plant^{-1} $MgSO_4$ (T_3). Significantly lower total leaf area 15.5 m^2 was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2). Turner and Barker (1983) also reported that low Mg supply reduced the mean leaf area growth rate on the plants.

Leaf area index (LAI)

The capacity of a canopy of leaves in a plantation to intercept light and fix carbon is measured by the leaf area index (LAI). The leaf area index was increased with the increase in magnesium level (Table 1). The treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) recorded significantly higher leaf area index 8.04, which was at par with GRDF + 40 g plant^{-1} $MgSO_4$ (T_5). Significantly lower leaf area index 6.89 was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2).

Days required for shooting and harvesting

The days required for shooting and harvesting were delayed with increase in the level of magnesium for banana (Table 2). The control treatment of GRDF (T_1) recorded minimum days for shooting (268 days), which was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2). The treatment GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) and GRDF + 40 g plant^{-1} $MgSO_4$ (T_5) recorded significantly more days for shooting (277 days).

Minimum days to harvest (360 days) were recorded in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2). The treatment GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) recorded significantly more days to harvest (372 days), which was at par with the treatment GRDF + 40 g plant^{-1} $MgSO_4$ (T_5).

Table 2: Days required for shooting and harvest, Chlorophyll content of banana as influenced by graded levels of magnesium.

Treatments	Days required for shooting	Days required for harvest	Chlorophyll content (mg g^{-1} fresh weight of leaves)
1. GRDF	268^{a}	360^{a}	0.953^{e}
2. GRDF + 10 g plant^{-1} $MgSO_4$	270^{ab}	362^{a}	0.982^{d}
3. GRDF + 20 g plant^{-1} $MgSO_4$	272^{bc}	365^{b}	0.997^{c}
4. GRDF + 30 g plant^{-1} $MgSO_4$	274^{c}	367^{b}	1.006^{bc}
5. GRDF + 40 g plant^{-1} $MgSO_4$	277^{d}	371^{cd}	1.011^{ab}
6. GRDF + 50 g plant^{-1} $MgSO_4$	277^{d}	372^{d}	1.019^{a}
SEm +	0.78	0.78	0.003
CD at 5 %	2.55	2.35	0.009

Total chlorophyll in leaves

The total chlorophyll content increased with increase in level of magnesium (Table 2). The treatment of GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) recorded significantly higher total chlorophyll content in banana leaves (1.019 mg g^{-1} fresh weight of leaves), which was at par with GRDF + 40 g plant^{-1} $MgSO_4$ (T_5). The treatment GRDF + 40 g plant^{-1} $MgSO_4$ (T_5) recorded the total chlorophyll content of 1.011 mg g^{-1} fresh weight of leaves. This treatment was at par with the treatment GRDF + 30 g plant^{-1} $MgSO_4$ (T_4), which recorded the total chlorophyll content of 1.006 mg g^{-1} fresh weight of leaves. Magnesium is a primary

Table 3: Yield contributing characters of banana as influenced by graded levels of magnesium.

Treatments	No. of hands per bunch	No. of fingers per bunch	Bunch weight (kg)	Yield ($t\ ha^{-1}$) area (m^2)
1. GRDF	10.9	159[d]	24.9[c]	110.7[c]
2. GRDF + 10 g $plant^{-1}$ $MgSO_4$	11.1	167[c]	25.7[bc]	114.0[bc]
3. GRDF + 20 g $plant^{-1}$ $MgSO_4$	11.4	174[b]	26.9[ab]	119.6[ab]
4. GRDF + 30 g $plant^{-1}$ $MgSO_4$	12.1	186[a]	27.4[a]	121.9[a]
5. GRDF + 40 g $plant^{-1}$ $MgSO_4$	11.8	179[b]	27.2[ab]	120.7[ab]
6. GRDF + 50 g $plant^{-1}$ $MgSO_4$	11.7	178[b]	26.7[ab]	118.4[ab]
SEm +	0.31	2.20	0.51	2.27
CD at 5 %	NS	6.64	1.54	6.84

constituent of chlorophyll and accounts for 15 to 20 per cent of the total Mg content of plants (Bybordi and Jasarat, 2010). Significantly lower total chlorophyll content of 0.953 mg g^{-1} fresh weight of leaves was observed in the control treatment of GRDF (T_1).

Yield parameters of banana

Number of hands per bunch

The number of hands per bunch of banana were non significant due to the application of magnesium (Table 3). The treatment of GRDF + 30 g $plant^{-1}$ $MgSO_4$ (T_4) recorded numerically higher number of hands per bunch (12.1). The control treatment of GRDF (T_1) recorded numerically lower number of hands per bunch (10.9).

Number of fingers per bunch

The number of fingers per bunch of banana were significantly influenced by the application of magnesium levels (Table 3). The treatment of GRDF + 30 g $plant^{-1}$ $MgSO_4$ (T_4) recorded significantly higher number of fingers per bunch (186). This treatment was followed by GRDF + 40 g $plant^{-1}$ $MgSO_4$ (T_5), which recorded 179 fingers per bunch. However, this treatment was at par with the treatment of GRDF + 50 g $plant^{-1}$ $MgSO_4$ (T_6), and GRDF + 20 g $plant^{-1}$ $MgSO_4$ (T_3). Significantly lower number of fingers per bunch (159) were observed in the control treatment of GRDF (T_1).

Bunch weight

The banana bunch weight was significantly influenced by the application of magnesium levels (Table 3). The treatment of GRDF + 30 g $plant^{-1}$ $MgSO_4$ (T_4) recorded significantly higher banana bunch weight (27.4 kg), which was at par with the treatment of GRDF + 40 g $plant^{-1}$ $MgSO_4$ (T_5), treatment of GRDF + 50 g $plant^{-1}$ $MgSO_4$ (T_6), and treatment of GRDF + 20 g $plant^{-1}$ $MgSO_4$ (T_3). An increase in leaf area index (LAI) results in better utilization of solar energy in banana plants (Stover, 1984), which is responsible for higher banana bunch weight. Significantly lower banana bunch weight (24.9 kg) was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g $plant^{-1}$ $MgSO_4$ (T_2).

Banana yield

The banana yield was significantly influenced by the application of magnesium levels (Table 3). The treatment of GRDF + 30 g $plant^{-1}$ $MgSO_4$ (T_4) recorded significantly higher banana yield (121.9 t ha^{-1}), which was at par with the treatment of GRDF + 40 g $plant^{-1}$ $MgSO_4$ (T_5), treatment of GRDF + 50 g $plant^{-1}$ $MgSO_4$ (T_6), and treatment of GRDF + 20 g $plant^{-1}$ $MgSO_4$ (T_3). Apart from the number of leaves or rate of production, total leaf area at any stage of growth is very critical in banana as it has a close bearing on photosynthetic efficiency reflecting on biomass production. Greater leaf area aids the plant to synthesize more metabolites exhibiting high photosynthetic rate during the period of growth and development (Mahadevan, 1988), which resulted in higher banana yield. Magnesium fertilization would have exerted positive effect on chlorophyll structure, enzyme activities, protein synthesis, carbon fixation and phosphate metabolism which would have lead to better growth and higher yield. Significantly lower banana yield (110.7 t ha^{-1}) was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g $plant^{-1}$ $MgSO_4$ (T_2).

Quality parameters of banana

Total sugar

The total sugar content banana fruit was significantly influenced by the application of magnesium levels (Table 4). The treatment of GRDF + 50 g $plant^{-1}$ $MgSO_4$ (T_6) recorded significantly higher total sugar content banana fruit (17.67 %). Magnesium aids in the formation of

Table 4: Quality parameters of banana as influenced by graded levels of magnesium.

Treatments	TSS (^{0}Brix)	Acidity (%)	Total Sugar (%)
1. GRDF	19.80	0.32	16.17[d]
2. GRDF + 10 g $plant^{-1}$ $MgSO_4$	19.98	0.32	16.52[cd]
3. GRDF + 20 g $plant^{-1}$ $MgSO_4$	20.02	0.31	16.82[bc]
4. GRDF + 30 g $plant^{-1}$ $MgSO_4$	20.12	0.31	17.23[ab]
5. GRDF + 40 g $plant^{-1}$ $MgSO_4$	20.14	0.30	17.55[a]
6. GRDF + 50 g $plant^{-1}$ $MgSO_4$	20.22	0.29	17.67[a]
SEm +	0.096	0.008	0.17
CD at 5 %	NS	NS	0.53

Table 5: Effect of magnesium on economy of banana

Treatments	Yield (t ha^{-1})	Monetary returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net Profit (Rs ha^{-1})	B:C ratio
GRDF	110.7	885245^{c}	346297	538948^{c}	2.56
GRDF + 10 g plant^{-1} $MgSO_4$	114.0	911909^{bc}	347769	564140^{bc}	2.62
GRDF + 20 g plant^{-1} $MgSO_4$	119.6	957060^{ab}	349239	607821^{ab}	2.74
GRDF + 30 g plant^{-1} $MgSO_4$	121.9	974836^{a}	350711	624125^{a}	2.78
GRDF + 40 g plant^{-1} $MgSO_4$	120.7	965237^{ab}	352181	613056^{ab}	2.74
GRDF + 50 g plant^{-1} $MgSO_4$	118.4	947461^{ab}	353653	593808^{ab}	2.68
SE	2.27	18123	—	18121	—
CD	6.84	54629	—	54625	—

sugars, oils and fats (Tisdale *et al.*, 1985). Mg supply might have enhanced the phloem transport of sugars to from the source i.e. leaf to sink i.e. fruit (Cakmak, 1994). This treatment was at par with GRDF + 40 g plant^{-1} $MgSO_4$ (T_5) and GRDF + 30 g plant^{-1} $MgSO_4$ (T_4). Significantly lower total sugar content banana fruit (16.17 %) was observed in the control treatment of GRDF (T_1). This treatment was at par with the treatment GRDF + 10 g plant^{-1} $MgSO_4$ (T_2).

Total soluble solids (TSS)

The total soluble solids (TSS) was non-significant due to the application of magnesium (Table 4). The treatment of GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) recorded numerically higher TSS (20.22 ^{0}Brix). The control treatment of GRDF (T_1) recorded numerically lower TSS (19.80 ^{0}Brix).

Titrable acidity

The titrable acidity was non-significant due to the application of magnesium (Table 4). The control treatment of GRDF (T_1) and treatment of GRDF + 10 g plant^{-1} $MgSO_4$ (T_2) recorded numerically higher titrable acidity (0.32 %). The treatment of GRDF + 50 g plant^{-1} $MgSO_4$ (T_6) recorded numerically lower titrable acidity (0.29 %).

Economics of magnesium application

The treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) recorded significantly higher monetary returns of Rs. 9,74,836 /- and net profit of Rs. 6,24,125 /- (Table 5). This treatment was at par with the treatment of GRDF + 40 g plant^{-1} $MgSO_4$ (T_5), GRDF + 20 g plant^{-1} $MgSO_4$ (T_3) and GRDF + 50 g plant^{-1} $MgSO_4$ (T_6), which recorded net monetary returns of Rs. 9,65,237 /-, Rs. 9,57,060 /- and Rs. 9,47,461 /- and net profit of Rs. 6,13,056 /-, Rs. 6,07,821 /- and 5,93,808 /-, respectively. The significantly lower net monetary returns of Rs. 8,85,245 /- and net profit of Rs. 5,38,948 /- was recorded by the control treatment of GRDF (T_1). The highest B:C ratio 2.78 was recorded by treatment of GRDF + 30 g plant^{-1} $MgSO_4$ (T_4) and the lowest B:C ratio 2.56 was recorded by the control treatment of GRDF (T_1).

Conclusion

The study concluded that application of 150:60:150 g $N:P_2O_5:K_2O$ per plant through fertigation (N and K_2O in 44 splits and P_2O_5 in 16 splits at weekly interval) +10 kg FYM per plant alongwith 30 g plant^{-1} $MgSO_4$ in 15 splits from 7th to 21st week through fertigation found beneficial in terms of growth and yield of banana, gross monetary returns, net profit and B:C ratio.

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