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Effect of Fish Bone Meal on Major Nutrients Uptake in Tomato

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A pot culture experiment was carried out to study the effect of fish bone meal application on uptake of major nutrients by tomato crop during the *rabi* season. Application of the mineral fertilizer (DAP) with raw and acidulated fish bone meal (RFBM and AFBM) at different levels were imposed and the

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nutrient content and uptakes of major nutrients by tomato plant and fruits were recorded. 187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as AFBM recorded significantly higher NPK uptake which led to enhancement in biomass of tomato crop.

Keywords: Fish bone meal; phosphorus; tomato; uptake.

1. INTRODUCTION

India is second largest producer of tomato in the world with production of 20.33 metric tonnes from an area of 0.84 million hectares and productivity is 24.20 t ha^{-1} [1]. Karnataka has an area of 0.07 million hectares under tomato with annual production of 2.10 metric tonnes and productivity is 30 t ha^{-1} [1]. Tomato (*Solanum lycopersicon* Mill.) is self-pollinated crop and is one of the most popular and widely grown vegetable crops all over the India. In the present scenario, mankind is Habitual of rock phosphate. It should be noted that phosphate rock is a non-renewable resource and the depletion of current economically exploitable deposits can be estimated at somewhere from 70 to 140 years. Further, it is expected that the growing population, change in lifestyle and diets bring about 50 to 100 per cent higher demand for phosphorus by 2050 [2].

Fish bone meal (FBM) is a commercially available product, which is made from the bones and leftover meat of fish by commercial fisheries. FBM is obtained by fish trimmings or drying the fish followed by grinding and it making it powder or cake. Fish bone meal consists of about 45 to 50 per cent protein, 32 to 35 per cent ash, 8 to 12 per cent of fat and 5 to 7 per cent moisture. It contains approximately 6 per cent N, 7 per cent P, 0.2 per cent K, 11 to 16 percent of Ca, 0.18 to 0.26 per cent of Mg and 0.3 to 0.4 per cent of S. The organic matter content in FBM ranges from 20 to 24 per cent. Chemical analyses of FBM indicate that it contains substantial amounts of organic matter, nitrogen, phosphorus and calcium. Therefore, could be used as an organic source of nutrients to crops. The effectiveness of MBM (meat bone meal) as a nitrogen fertilizer to wheat has been evaluated by Nogalska and Załuszniewska [3]. They found better use of nitrogen from MBM than from pig slurry and the N content of the fertilizer was as effective as urea-N. This indicates that bone meal is a better P source than the commonly used phosphate rock. As the dissolution of $Ca_5(PO_4)_3OH$ in the bones requires H^+ions, pH is an important factor influencing P release from bone meal. The main aim of this investigation was to determine the effectiveness of FBM as a source of nutrients for tomato crop.

2. MATERIALS AND METHODS

A pot experiment was conducted at College of Agriculture, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga which is situated in Southern Transitional Zone of Karnataka (Agro-climatic Zone - VII) at 13°42' N latitude and 75°51' E longitude with an altitude of 667.5 m above mean sea level during *rabi* season of 2021. The soil was slightly acidic in pH, low in available nitrogen, medium in available phosphorus and potassium. Tomato hybrid SAKATA-914 was used for the experimentation having crop period from 110 to 120 days yielding attractive red color tomato berries. The experiment was conducted in complete randomized block design and replicated thrice. The treatment details are given in the Table 1.

Nitrogen and phosphorus were applied through urea and DAP, while potash was applied using muriate of potash (MOP). Full quantity of phosphorus, potassium and half quanity of nitrogen were applied as basal dose at the time of planting. Remaining quantity of nitrogen was applied four weeks after planting. The contribution of N and P from the fish bone meal and acidulated fish bone meal was taken into consideration during the application of fertilizers. The phosphorus solubilising and mobilizing fungi such as *Aspergillus awamori* and *Glomus fasciculatum* (VAM) were applied to all the treatments.

2.1 Soil Analysis

The soil samples collected from each pot were dried under shade, powdered using wooden pestle and mortar, passed through 2 mm sieve for the soil analysis. Soil pH and EC were determined using methods given by Jackson [4]. Available nitrogen in the soil was determined by alkaline potassium permanganate method as described by Subbiah and Asija [5]. Available phosphorus was extracted from the soil using Bray's No.1 (0.03 N NH_4F + 0.025 N HCl) and

Olsen's (0.5 M $NaHCO_3$) extractant depending on soil pH. The concentration of phosphorus in the extract was determined by chlorostannous reduced molybdo-phosphoric acid blue colour in HCl system using a spectrometer [4]. Available potassium was extracted from the soil using neutral normal ammonium acetate and was determined by flame photometer [4].

2.2 Plant Analysis

The representative plant and fruit samples were collected from individual plants in each replication and were crushed, shade dried first, dried in hot air oven later at 60 ºC and stored for further analysis. Total nitrogen was determined by Kjeldhal's method, total phosphorous and potassium content were estimated using the vanado-molybdo phosphoric yellow colour method and flame photometric method, respectively as described by Jackson [4]. The nutrient uptake by the crop was calculated using the following formula given below.

Nutrient uptake (kg ha^{-1}) = Nutrient Concentration (%) × Dry matter (kg ha^{-1}) *100

2.3 Statistical Analysis

Fisher's method of analysis of variance was adopted for statistical analysis and interpretation of the data. The treatments were tested at five per cent levels of significance. The analysis was carried out by following the methodology described by Sundararaj et al. [6].

Table 1. Treatment details of the experiment

Treatment	Details
T_1	Control
T_2	250 kg P_2O_5 as DAP (Package of Practice)
T_3	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as RFBM
T_4	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as RFBM
T_5	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as AFBM
T_6	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as AFBM
T_7	200 kg P_2O_5 as DAP (80 % recommended P_2O_5)
T_8	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as RFBM
T_9	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as RFBM
T_{10}	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as AFBM
T_{11}	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as AFBM

Table 2. Effect of fish bone meal on total nitrogen content and uptake by tomato

Treatments		Content (%)			Uptake (g pot^{-1})		
		Plant	Fruit	Total	Plant	Fruit	Total
T_1	Control	1.19	1.58	2.77	0.29	4.14	4.43
T_2	250 kg P_2O_5 as DAP (Package of Practice)	1.33	1.73	3.06	0.43	7.43	7.86
T_3	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as RFBM	1.28	1.70	2.98	0.36	6.66	7.02
T_4	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as RFBM	1.32	1.71	3.03	0.40	7.27	7.67
T_5	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as AFBM	1.36	1.78	3.14	0.51	8.06	8.57
T_6	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as AFBM	1.35	1.75	3.1	0.48	7.52	8.00
T_7	200 kg P_2O_5 as DAP (80 % recommended P_2O_5)	1.23	1.66	2.89	0.33	5.62	5.95
T_8	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as RFBM	1.20	1.63	2.83	0.30	4.99	5.29
T_9	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as RFBM	1.22	1.65	2.87	0.31	5.11	5.42
T_{10}	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as AFBM	1.25	1.69	2.94	0.34	6.23	6.57
$\mathbf{T_{11}}$	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as AFBM	1.24	1.67	2.91	0.33	6.14	6.47
SEm ±		0.01	0.02	0.02	0.01	0.22	0.22
CD (5%)		NS	NS	NS	0.03	0.65	0.67

3 RESULTS AND DISCUSSION

3.1 Nitrogen Content and Uptake in Plant and Fruit of Tomato

The data pertaining to nitrogen content and its uptake at final harvest of tomato is listed in Table 2. The N content in tomato plant didn't influence significantly by fish bone meal application. The higher N content in tomato was recorded in treatment T_5 (1.36 % in plant and 1.78 % in fruit) receiving 75 per cent recommended P through DAP and remaining 25 per cent through AFBM. This might be due to the fact that, VAM and PSF inoculation solubilized and mobilised the continues phosphorus availability, increased in growth and development, resulting in better absorption and utilization of all plant nutrients, that lead to maximum nitrogen and phosphorus content and uptake by shoot and fruits.

The nitrogen uptake by tomato plant and fruit at harvest shown that treatment T_5 recorded significantly highest uptake in both plant and fruit (0.51g pot^{-1} and 8.06g pot^{-1}, respectively), treatment T_6 (0.48 g pot^{-1} and 7.52 g pot^{-1}), T_2 (0.43 g pot^{-1} and 7.43 g pot^{-1}) and T_4 (0.40 g pot^{-1} and 7.27 g pot^{-1}) were on par with each other. Nogalska and Załuszniewska, [3] reported increased N uptake with increasing N fertilization for both for MBM and mineral fertilizer in field experiments. Nogalska *et al.* (2017) reported increased MBM doses contributed to a significant increase in the content of mineral nitrogen and phosphorus in the soil.

3.2 Phosphorus Content and Uptake in Plant and Fruit of Tomato

The data pertaining to phosphorus content and its uptake by plant and fruit are summarized in Table 3. Phosphorus content was significantly higher in treatment T_5 (0.48 % in plant and 0.35 % in fruit). The treatment T_6, T_2, T_3 and T_4 were on par with each other. The lowest phosphorus content in tomato was recorded in treatment T_1 (control) (0.24 % in plant and 0.21 % in fruit). The phosphorus content in tomato fruit was not influenced significantly by the application of fish bone meal, although the higher phosphorus content in tomato fruit was recorded in the treatment T_5. The higher concentration of phosphorus at all the stage of tomato in T_5 treatment is due to continues availability of phosphorus initially from DAP fertilizer and in later stages of crop due to solubility of AFBM and RFBM. The ability of phosphorus solubilizing fungi (PSF) to transform insoluble phosphate in the soil into soluble forms by secreting organic acids resulting in effective solubilization and utilization of phosphate. Inoculation with PSF increased the content of phosphorus in the plant Ahmad *et al*. [7] Rawat *et al.* [8] observed that phosphate solubilizing microorganisms play a significant role in the solubilization and uptake of native and applied soil phosphorus. Nogalska *et al.* [9] and Załuszniewska and Nogalska [10] also reported the beneficial influence of MBM on phosphorus content in different crops.

It was also observed from the results given in Table 3 that treatment T_5 recorded significantly highest uptake of P (0.18 g pot^{-1}) by plant. Treatment T_1 recorded lowest P uptake (0.06 g pot^{-1}) in plant. Data recorded for phosphorus uptake in fruit showed significantly highest P uptake (1.59 g pot^{-1}) in treatment T_5, which was on par with T_6 and T_2 (1.37 and 1.34 g pot^{-1}, respectively). In contrast, treatment T_1 recorded the lowest uptake of P (0.56 g pot^{-1}) in fruit. Jatana *et al*. [11] reported the application of both arbuscular mycorrhizal fungi (AMF) and *Penicillium bilaiae* in association with meat bone meal (MBM) resulted in improved mobilization of phosphorus and subsequent P uptake by maize (*Zea mays*). Meat bone meal biochar had an ability to supply a substantial amount of phytoavailable P for plant uptake and increased phosphorus availability in post-harvest soils [12].

3.3 Potassium Content and Uptake in Plant and Fruit of Tomato

The data pertaining to potassium content and its uptake by plant and fruit are summarized in Table 4. A non-significant difference was observed in the K content of plant and fruit due to application of fish bone meal. Higher K content observed with treatment T_5 (0.94 % in plant and 1.33 % in fruit). The lowest K content in tomato was recorded in the treatment T_1 (control) (0.63 % in plant and 1.25 % in fruit). The K content in tomato fruits was not influenced significantly by the application of fish bone meal although the higher K content in tomato fruits was recorded under the treatment T_5.

It was also observed from the results that treatment T_5 recorded significantly highest uptake of K by plant and fruit of tomato (0.35 g pot^{-1} and 6.04 g pot^{-1}, respectively) which was on par with T_6 and T_2. The lowest K uptake in fruit (3.30 g pot^{-1}) and plant (0.15 g pot^{-1}) were

Table 3. Effect of fish bone meal on total phosphorus content and uptake by tomato

Treatments		Content (%)			Uptake (g pot^{-1})		
		Plant	Fruit	Total	Plant	Fruit	Total
T_1	Control	0.24	0.21	0.45	0.06	0.56	0.62
T_2	250 kg P_2O_5 as DAP (Package of Practice)	0.39	0.31	0.70	0.13	1.34	1.47
T_3	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as RFBM	0.38	0.29	0.67	0.11	1.14	1.25
T_4	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as RFBM	0.38	0.30	0.68	0.12	1.26	1.38
T_5	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as AFBM	0.48	0.35	0.83	0.18	1.59	1.77
T_6	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as AFBM	0.42	0.32	0.74	0.15	1.37	1.52
T_7	200 kg P_2O_5 as DAP (80 % recommended P_2O_5)	0.34	0.26	0.60	0.09	0.87	0.96
T_8	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as RFBM	0.31	0.25	0.56	0.08	0.76	0.84
T_9	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as RFBM	0.33	0.26	0.59	0.08	0.81	0.89
T_{10}	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as AFBM	0.37	0.28	0.65	0.10	1.02	1.12
T_{11}	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as AFBM	0.36	0.27	0.63	0.10	1.00	1.10
SEm ±		0.04	0.03	0.03	0.01	0.11	0.11
CD (5%)		0.11	NS	0.04	0.04	0.31	0.34

Table 4. Effect of fish bone meal on total potassium content and uptake by tomato

Treatments		Content (%)			Uptake (g pot^{-1})		
		Plant	Fruit	Total	Plant	Fruit	Total
T_1	Control	0.63	1.25	1.88	0.15	3.30	3.45
T_2	250 kg P_2O_5 as DAP (Package of Practice)	0.83	1.32	2.15	0.27	5.66	5.93
T_3	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as RFBM	0.81	1.30	2.11	0.23	5.08	5.31
T_4	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as RFBM	0.82	1.31	2.13	0.25	5.58	5.83
T_5	187.5 kg P_2O_5 as DAP + 62.5 kg P_2O_5 as AFBM	0.94	1.33	2.27	0.35	6.04	6.39
T_6	125 kg P_2O_5 as DAP + 125 kg P_2O_5 as AFBM	0.89	1.32	2.21	0.31	5.98	6.29
T_7	200 kg P_2O_5 as DAP (80 % recommended P_2O_5)	0.76	1.27	2.03	0.20	4.30	4.50
T_8	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as RFBM	0.72	1.26	1.98	0.18	3.86	4.04
T_9	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as RFBM	0.74	1.27	2.01	0.19	3.94	4.13
T_{10}	150 kg P_2O_5 as DAP + 50 kg P_2O_5 as AFBM	0.78	1.28	2.06	0.21	4.72	4.93
T_{11}	100 kg P_2O_5 as DAP + 100 kg P_2O_5 as AFBM	0.77	1.26	2.03	0.21	4.62	4.83
SEm ±		0.11	0.03	0.05	0.03	0.23	0.11
CD (5%)		NS	NS	NS	0.10	0.68	0.33

observed in T_1 treatment. In case of the total K uptake by tomato, the highest total uptake (6.39 g pot^{-1}) was recorded with treatment T_5 followed by the treatment T_6 (6.29 g pot^{-1}) and these were significantly superior over other remaining treatments. In contrast, the lowest total uptake of K (3.45 g pot^{-1}) was recorded with T_1 treatment. The increased content of K might be due to the application of N and P, which increased the K content in the plant [13] Phosphorus fertilization helps in promoting root growth which leads to increased content and uptake of K by the crop. It indicates the application of phosphorus through integrated sources seems to be beneficiary for the absorption of N, P and K by the plants. These results are in conformity with those of Mitran *et al.* [14], Khan *et al*. [15] and Wang et al. [16]

4. CONCLUSION

Application of 75 per cent of recommended P through mineral fertilizer and remaining through AFBM (T_5) recorded significantly higher nutrient content and uptake of nitrogen, phosphorus and potassium in tomato plant and fruit. This approach presents a promising strategy for optimizing nutrient utilization and enhancing crop productivity. Further research into its long-term effects and potential scalability is warranted to ascertain its broader applicability in sustainable agriculture practices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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