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Effect of micronutrient fortified Konkan Annapurna Briquettes on yield of Alphonso mango (*Mangifera indica* L.) in lateritic soils of Konkan

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Abstract
An investigation entitled "Effect of micronutrient fortified Konkan Annapurna Briquettes on yield of Alphonso mango (*Mangifera indica* L.) in lateritic soils of Konkan" was undertaken in mango orchard of Department of Horticulture, College of Agriculture, Dapoli during the year 2016-17 and 2017-18. The field experiment was laid out in Randomized Block Design with three replications and ten treatments comprising of absolute control (T_1), Recommended Dose of Fertilizers (RDF) (T_2), RDF + copper through copper sulphate @ 15 kg ha^{-1} (T_3), RDF + boron through borax @ 10 kg ha^{-1} (T_4), RDF + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} (T_5), RDF + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} (T_6), 100 per cent RDN through Konkan Annapurna Briquettes (KAB) (T_7), 100 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (KAB) (T_8), 80 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (KAB) (T_9) and 60 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (KAB) (T_{10}) and FYM @ 50 kg tree^{-1} was applied to all the treatments.
The application of 50 kg FYM tree^{-1} + 100 per cent Recommended Dose of Nitrogen + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (T_8) recorded the significantly highest mango yield per tree (67.53 kg tree^{-1} in first year and 80.07 kg tree^{-1} in second year) and maximum number of fruits (271.04 in first year and 304.37 in second year). The treatment T_1 *i.e.* absolute control recorded the significantly lowest mango yield per tree (21.62 kg tree^{-1} in first year and 19.63 kg tree^{-1} in second year) and minimum number of fruits (97.03 in first year and 83.70 in second year).

Keywords: Konkan Annapurna briquettes, Alphonso mango *Mangifera indica* L.

Introduction
Mango (*Mangifera indica* L.) popularly known as 'King of fruits' and 'Nectar of God' belongs to the family Anacardaceae. Being most palatable and rich in sugars, organic acids and minerals, it captures great demand in all walks of life (Azhar *et al*., 2007) [1]. India is bestowed with mango germplasm, thus able to produce more than 1000 varieties in the country. Alphonso tops the list and is grown along the west coast of India particularly in Gujarat, Maharashtra, Goa and Karnataka and covers more than 80 per cent of the total mango export (Burondkar *et al*., 2009) [4]. It is one of the choicest and prime variety of India for its unique sugar-acid blend, attractive colour, pleasent aroma, superior fragrance, highly appreciable flavour, delicious taste and long keeping quality (Shinde *et al*., 2009) [18].
The Konkan region of Maharashtra is well known for mango. The two districts of the region *viz*., Ratnagiri and Sindhudurg, in particular are known as 'Mango baskets'. Today the mangoes grown in these districts carry the GI tag and are marketed as the very special Ratnagiri and Devgad Alphonso or Hapoos. Alphonso, the most popular and prime mango variety which is chiefly produced in the two districts largely contributes to the economy of these districts.
However, the productivity of Alphonso is low in spite of the area under cultivation. The low productivity and yield fluctuation of the Alphonso mango in Konkan region has several reasons of which the fertility status of the soil is one of the most important factor. In addition, inadequate use of manures and fertilizers along with imbalance of nutrients are also responsible for low yield. The soil of Ratnagiri district in which mango is grown, is mainly lateritic and hence, there is a heavy nutrient loss of some of the macro and micronutrients,

possibly due to heavy rainfall and undulating terrain (Pereira *et al*., 1986) [14]. Improper management practices which include under nutrition and negligence of orchards also affect the yield (Reddy *et al*., 2003) [17]. The yield of mango are dependent on adequacy and balance of plant nutrient elements in the trees before bearing and harvesting (Pathak and Pandey, 1978; Singh and Dhillon, 1993) [12, 20].

Mango trees largely suffer due to the deficiency of macro and micronutrients. These nutrients if supplied in the right amounts and at the right time, are sure to boost up the economic yield of the tree.

After the green revolution, increase in production was achieved at the cost of soil health. It has been proved use of organic manures to meet the nutrient requirements of crop would be an inevitable practice in the years to come for sustainable agriculture since organic manures not only improve the soil physical, chemical and biological properties (Heitkamp *et al.,* 2011) [6] but also improves the moisture holding capacity of soil, thus resulting in enhanced crop productivity alongwith better quality of crop produce (Premsekhar and Rajashree, 2009) [15]. Hence fertilizers and manures in combinations could be used to enhance nutrient supplying capacity of the soil (Dutta and Sangtam, 2014) [5].

As a result of surge in demand and inadequate domestic production, there was heavy import of the three major nutrients, *viz.*, nitrogen, phosphorous and potassium despite high international prices. Also the efficiency of nitrogen added through straight fertilizers is about 50 per cent or even less, for phosphorous is about 20 per cent and for potassium it is about 60 per cent (Balligar and Bennett, 1986) [2]. The low use efficiency of nitrogen is because of volatilization, denitrification, surface runoff, leaching losses and ammonia fixation in the soil. The phosphate fixation capacity of the soil is very high (about 80 %) resulting in its unavailability (Kadrekar *et al*., 1981) [8]. Same is the case with potassium. In order to reduce the import demand and to ensure the efficient use of fertilizers, attempts were made to use the fertilizers in the form of briquettes. The briquettes release the nutrients slowly, thereby reduce the amount of fertilizer washed away by rain or absorbed by the air. In addition to the three major nutrients, *viz.* nitrogen, phosphorous and potassium, micronutrients *viz*., copper, boron, molybdenum, *etc.* can be added during preparation of the briquettes in order to make them nutrient dense and to reduce the application cost.

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli has recommended the use of Konkan Annapurna Briquettes (KAB) for rice crop in *kharif* season. Till date, lot of research has been conducted on the application of plant nutrients in the form of briquettes in submerged soil in rice. Increase in growth, yield, quality, content and uptake of nutrients by plants with the application of briquette has been reported earlier by number of workers in different vegetable crops *viz*., chilli, cucumber, dolichos bean, okra, *etc*. and plantation crops like arecanut and cashewnut. However, the data on use of fertilizer briquette in mango to improve the yield is meager. Keeping these points in view, the present investigation was undertaken.

Material and Methods

A field trial was conducted since June, 2016 to May, 2017 and June, 2017 to May, 2018 in a forty five years old mango orchard at Plot No. 14, Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.). For this investigation, 60 mango grafts of Alphonso cultivar having uniform growth and vigour grown under rainfed condition from mango orchard have been selected. The field experiment was laid out in a Randomized Block Design (RBD) comprising of ten treatments with three replications. The experimental data obtained were subjected to statistical analysis by the technique of analysis of variance as applicable to randomized block design as per the procedure given by Panse and Sukhatme (1967) [11].

The briquettes were prepared as per the ratio of fertilizers combination. For treatment T_7, required quantity was taken through complex fertilizer *i.e.* Godavari (14:35:14) and urea in 1:1.5 ratio for the preparation of briquettes. Whereas, for treatments T_8, T_9 and T_{10}, the calculated quantity of micronutrients like copper (copper sulphate), boron (borax) and molybdenum (sodium molybdate) were mixed in the constituents of the briquettes.

The FYM was applied in first fortnight of June while, fertilizers and briquettes were applied in the ring periphery of the tree in second fortnight of June during both the years. Each experimental tree was treated with soil application of Pachlobutrazol (3 ml m^{-1} canopy diameter) in month of July, 2016 and 2017 to avoid the alternate bearing.

Table 1: Details of the treatments applied

Tr. No.	Description of the treatment
T_1	Absolute control (No Manure, No Fertilizer)
T_2	RDF (1.5:0.5:1.0 kg N: P_2O_5 : K_2O $tree^{-1}$ $year^{-1}$)
T_3	RDF + Copper through Copper Sulphate @ 15 kg ha^{-1}
T_4	RDF + Boron through Borax @ 10 kg ha^{-1}
T_5	RDF + Molybdenum through Sodium Molybdate @ 0.250 kg ha^{-1}
T_6	RDF + Copper through Copper Sulphate @ 15 kg ha^{-1} + Boron through Borax @ 10 kg ha^{-1} + Molybdenum through Sodium Molybdate @ 0.250 kg ha^{-1}
T_7	100 % RDN through Konkan Annapurna Briquettes (KAB)
T_8	100 % RDN + Copper through Copper Sulphate @ 15 kg ha^{-1} + Boron through Borax @ 10 kg ha^{-1} + Molybdenum through Sodium Molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (KAB)
T_9	80 % RDN + Copper through Copper Sulphate @ 15 kg ha^{-1} + Boron through Borax @ 10 kg ha^{-1} + Molybdenum through Sodium Molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (KAB)
T_{10}	60 % RDN + Copper through Copper Sulphate @ 15 kg ha^{-1} + Boron through Borax @ 10 kg ha^{-1} + Molybdenum through Sodium Molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (KAB)

(Note: FYM @ 50 kg $tree^{-1}$ was applied to all the treatments; RDF- Recommended Dose of Fertilizers; RDN- Recommended Dose of Nitrogen)

Results and Discussion

Effect of micronutrient fortified Konkani Annapurna Briquettes on number of fruits $tree^{-1}$

The data regarding No. of fruits $tree^{-1}$ are presented in Table 2. During both the years of experiment, the treatment T_8

consisting 50 kg FYM + 100 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes was significantly superior in recording maximum number of fruits (271.04 tree^{-1} and 304.37 tree^{-1}) as compared to all other treatments expect treatment T_9 (269.37 tree^{-1} and 296.04 tree^{-1}). Both the treatments were at par with each other.

In general, due to application of manure and fertilizers through different treatments the yield in mango orchard was found to be increased over absolute control during both years of the experiment. Patil (2017) [13] also observed that the application of recommended dose + 100 per cent extra recommended dose significantly yielded highest number of fruits (320 tree^{-1}) over absolute control treatment where manures and fertilizers were not applied.

Effect on average weight of fruit

It was observed from the data that, the average weight of fruit did not show any statistical differences due to application of manure, fertilizers and micronutrient fortified Konkan Annapurna Briquettes. Singh *et al.* (1977) [19] found that when urea was applied to the soil as 200 or 400 g per tree, all the treatments increased mango fruit weight as compared to absolute control. Patil (2017) [13] observed the same range of average weight of fruit for alphonso mango.

Effect on yield (kg tree^{-1} and t ha^{-1})

During first year (2016-17), the treatment T_8 comprising of 50 kg FYM + 100 per cent Recommended Dose of Nitrogen through micronutrient fortified Konkan Annapurna Briquettes recorded maximum yield of Alphonso mangoes (67.53 kg tree^{-1} and 6.75 t ha^{-1}) which was at par with treatment T_9 (64.76 kg tree^{-1} and 6.48 t ha^{-1}) and T_6 (59.03 kg tree^{-1} and 5.90 t ha^{-1}). However, during second year (2017-18), the treatment T_8 *i.e.* FYM @ 50 kg + 100 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes recorded maximum yield of Alphonso mangoes (80.07 kg tree^{-1} and 8.01 t ha^{-1}) which was significantly higher over all other treatments but at par with treatment T_9 consisting FYM @ 50 kg + 80 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (76.36 kg tree^{-1} and 7.64 t ha^{-1}). It indicated that the application of 80 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes could save 20 per cent nitrogen and gave much yield as that of 100 per cent RDN + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes.

In comparison of both years, an increasing trend of fruit yield from first year to second year was noticed (except absolute control treatment) due to application of manure, fertilizers and micronutrient fortified Konkan Annapurna Briquettes. The increase in fruit yield during second year might be due to combined effect of manures, fertilizers and briquettes applied during second year as well as the residual impact of the same applied during first year. Also the yield of Alphonso mango increased significantly in the treatments, where nutrients were applied in the form of briquettes as compared to the treatments where nutrients were applied through straight fertilizers.

In general, due to application of manure and fertilizers through different treatments the fruit yield in mango orchard was found to be increased over absolute control during both years of the experiment. The cause for getting higher yield in all the treatments comprising fertilizers may be due to higher nutrient content in soil and leaf throughout the year in mango orchard. The higher soil and leaf nutrient status at various stages might be attributed to regular, proper and recommended application of nutrients in the orchard. The total phosphorous and calcium content in the leaf proved that they were beneficial in increasing the yield of mango. These observations are in conformity with the results obtained by More (2013) [10], Joshi (2015) [7], Puranik, (2015) [16] and Patil (2017) [13]. Karle (2004) [9] from his study revealed that due to application of N, P, K and organic manures in soil, there was increase in fruit yield from 19.78 to 48.21 kg tree^{-1} over absolute control in Alphonso mango. Bhupalraj and Rao (2006) [3] observed that the application of macro and micro nutrients through soil and leaf increased yield in Baneshan mango. Patil (2017) [13] also observed the application of recommended dose + 100 per cent extra recommended dose significantly produced highest yield (98.89 and 90.43 kg tree^{-1}) over absolute control treatment.

Table 2: Effect of micronutrient fortified Konkan Annapurna Briquettes on No. of fruits, average weight and yield of Alphonso mango

Treat. No.	2016-17				2017-18			
	No. of fruits (tree^{-1})	Average wt. of fruit (kg)	Yield (kg tree^{-1})	Yield (t ha^{-1})	No. of fruits (tree^{-1})	Average wt. of fruit (kg)	Yield (kg tree^{-1})	Yield (t ha^{-1})
T_1	97.03	0.225	21.62	2.16	83.70	0.238	19.63	1.96
T_2	162.50	0.254	41.10	4.11	199.17	0.267	53.25	5.32
T_3	175.06	0.261	45.78	4.58	208.39	0.278	57.92	5.79
T_4	176.56	0.266	46.76	4.68	213.23	0.283	60.31	6.03
T_5	189.37	0.263	49.80	4.98	222.71	0.279	62.48	6.25
T_6	217.48	0.271	59.03	5.90	234.14	0.288	67.35	6.74
T_7	187.09	0.234	43.73	4.37	220.43	0.251	55.49	5.55
T_8	271.04	0.249	67.53	6.75	304.37	0.263	80.07	8.01
T_9	269.37	0.241	64.76	6.48	296.04	0.258	76.36	7.64
T_{10}	169.69	0.237	40.32	4.03	178.02	0.250	43.73	4.37
Mean	191.52	0.250	48.04	4.80	216.02	0.265	57.66	5.77
S.E. (m)±	11.970	0.011	3.149	0.315	12.548	0.011	3.763	0.376
C.D. (P=0.05)	35.565	NS	9.355	0.935	37.282	NS	11.182	1.118

Conclusion

Application of FYM @ 50 kg tree^{-1} + 100 per cent Recommended Dose of Nitrogen + copper through copper sulphate @ 15 kg ha^{-1} + boron through borax @ 10 kg ha^{-1} + molybdenum through sodium molybdate @ 0.250 kg ha^{-1} through Konkan Annapurna Briquettes (T_8) was responsible for getting higher yield of Alphonso mango.

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