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Application of different levels of NPK along with soil and foliar application of zinc and boron in cashew for increasing production with sustainability

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Abstract
The effect of different levels of nitrogen, phosphorus and potassium along with soil and foliar application of zinc and boron on yield and quality of cashew nut (*Annacardium occidentale* L.) Variety Vengurla-4 in lateritic soil of Konkan has been studied during May 2016 to April 2017 in Randomized Block Design with four levels of NPK (1.0:0.25:0.25, 1.0:0.50:0.50, 1.5:0.75:0.75 and 2.0:1.0:1.0 kg NPK per tree) with or without soil application of boron through borax @ 50g + zinc through zinc sulphate @ 125g/tree or foliar application of boron through borax @ 0.25% + zinc through zinc sulphate @ 0.5% /tree, an absolute control (to judge the fate of native nutrients) comprising thirteen treatments replicated thrice. It is revealed from the study that 12.80 to 44.09 per cent increase in the yield of cashew nut was recorded during 2016-17 with application of different levels of nitrogen, phosphorus and potassium along with soil or foliar application of boron through borax and zinc through zinc sulphate. The highest yield of cashew nut per tree (10.36 kg $tree^{-1}$) and number of nuts per kg were was recorded with the application of recommended dose of fertilizer + soil application of boron through borax @ 50 g + zinc through zinc sulphate @ 125g/tree (treatment T_6). Application of 2.0:1.0:1.0 NPK kg/ tree + boron through borax @0.25%+ zinc through zinc sulphate @ 0.5%/tree (T_{13}) recorded significantly higher organic carbon and available Mn in the soil. Application of fertilizer levels @1.0:0.25:0.25 NPK kg/tree + boron through borax @ 0.25%+ zinc through zinc sulphate @0.5%/tree (T_{10}) recorded significantly higher available nitrogen and zinc in the soil. All these treatments were at par with the application 1.0:0.50:0.50 kg NPK per tree along with spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5% (T_{11}). By considering the higher yield of cashew nut, chemical properties of soil and availability of nutrients in the soil, application 1.0:0.50:0.50 kg NPK per tree along with spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5% found to be beneficial in lateritic soils of Konkan.

Keywords: Cashewnut, available NPK, Zn, B, foliar spray, lateritic soil

Introduction

Results and Discussion

Yield

The yield of cashew nut varied from 7.19 to 10.36 kg $tree^{-1}$, Application of different levels of inorganic fertilizers with soil and foliar application of Zn and B significantly increased the yield of cashew nut per tree over the absolute control i.e. no fertilizer application. 12.80 to 44.09 per cent increase in the yield of cashew nut was recorded. The number of nuts per kg were not influenced by different levels of inorganic fertilizers with soil and foliar application of Zn and B and statistically found to be non-significant. Application of different levels of inorganic fertilizers with soil and foliar application of Zn and B numerically increased the number of nuts per kg over the absolute control i.e. no fertilizer application. The highest number of nuts per kg (142 number of nuts kg^{-1}), were noted with the treatments T_6 (1.0:0.25:0.25 kg NPK + Soil application of B+Zn and T_{11} (1.0:0.50:0.50 kg NPK + Foliar application of B+Zn). The average weight of nut varied from 6.58 to 7.07 g. In general, application of nitrogen, phosphorus and potassium significantly increased the number of nuts and the total weight of nuts per plant. Potassium plays a vital role in the formation or synthesis of amino acid and proteins from ammonium ions which are absorbed by the plant (Raheja, 1971) [11].

It also plays an important role in the maintenance of cellular organization by regulating the permeability of cellular membranes and keeping the protoplasm in a proper degree of hydration by stabilizing the emulsion of highly colloidal particles (Ghose, 1990 and Kanwar, 1976) [6].

The application of fertilizer levels + foliar application of boron through borax @ 0.25% +zinc through zinc sulphate @ 0.5% per tree (treatment T_{10}) recorded the highest average weight of nut (7.07 g) which was significantly superior over all the treatments followed by T_8 (1.5:0.75:0.75 kg NPK + Soil application of B+Zn) (6.91 g), where treatment T_8 was at par with T_4, T_5, T_6, T_7, T_8, T_9, T_{11}, T_{12} and T_{13}.

Soil properties

The highest soil pH and EC at new emergence shoot stage, at flowering stage, at nut setting stage and at harvest stage were observed in treatment T_{11} i.e.1.0:0.50:0.50 kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; where in case of pH, treatment T_{11} was at par with T_2 at new emergence shoot stage; with T_2, T_5, T_6, T_8, T_{10} and T_{12} at flowering stage; with T_2, T_7 and T_{13} at nut setting stage and with T_7 at harvest stage; while in case of EC, treatment T_{11} was at par with T_3 and T_{13} at new emergence shoot stage; with all other treatments except T_1 and T_{11} at flowering stage; with T_4, T_6, T_9, T_{10}, T_{12} and T_{13} at nut setting stage and with T_3, T_7 and T_8 at harvest stage.

Similar ranges of pH and EC of soils of cashew orchard Cv. Vengurla-4 grown on lateritic soils of Konkan at new emergence shoot stage, flowering stage, nut setting stage and harvest stage were also reported by Palsande (2011) [10] and Palkar (2014) [9]. Over all, a critical examination of the data showed that electrical conductivity increased from new emergence stage to flowering stage and thereafter no specific trend of increase or decrease was observed at nut setting stage and at harvest stage.

A non-significant effect of different levels of inorganic fertilizers alone or with soil and foliar application of Zn and B on organic carbon content in the soils was observed at new emergence stage and at flowering stage, while the significant effect was observed at nut setting stage and at harvest stage during both years. Numerically highest organic carbon content i.e. 24.53 g kg^{-1} at new emergence shoot stage and 23.59 g kg^{-1} at flowering stage and statistically highest organic carbon content i.e. 21.20 g kg^{-1} at nut setting shoot stage and 20.74 g kg^{-1} at harvest stage was observed in treatment T_{13} i.e. 2.0:1.0:1.0 kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; where treatment T_{13} was at par with T_3 and T_{10} at nut setting stage and with T_2, T_3, T_6, T_8, T_9, T_{10}, T_{11} and T_{12} at harvest stage. Over all, a critical examination of the data showed that organic carbon content in soils decreased from new emergence stage to harvesting stage.

Available nutrients

Available nitrogen in soils decreased from new emergence stage to harvesting stage. Significantly highest available nitrogen i.e. 382.62 kg ha^{-1} at new emergence shoot stage and 320.56 kg ha^{-1} at flowering stage and highest organic carbon content i.e. 434.22 kg ha^{-1} at nut setting shoot stage and 280.73 kg ha^{-1} at harvest stage was observed in treatment T_{10} i.e. 1.0:0.25:0.25 kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; where treatment T_{10} was significantly superior over all the treatments at new emergence shoot stage, at nut setting stage and at harvest stage, while treatment T_{10} was at par with T_9 at flowering stage. Treatment T_{10} was followed by T_{13} at new emergence shoot stage and T_8 at nut setting stage, while T_5 at harvest stage where T_5 was at par with T_6 and T_{12}.

In general, the data indicated that the soil having high organic matter content showed high available N and the increase in organic matter may be due to accumulation of leaf litter fall during the period of fruit development as the numbers of leaves were enhanced with foliar spray over the control. This finding could be supported by Dhopavkar (2001) [3] who reported appreciable increase in available N content in soil particularly with addition of organic matter. Organic matter mineralization provides a continuous, although limited, supply of plant available N, in addition to P and S (Tisdale *et al*., 1995) [14].

Significantly highest available phosphorus i.e. 26.17 kg ha^{-1} at new emergence shoot stage, 24.87 kg ha^{-1} at flowering stage, 24.87 kg ha^{-1} at nut setting shoot stage and 24.70 kg ha^{-1} at harvest stage, was observed in treatment T_{12} i.e. 1.5:0.75:0.75 kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; where treatment T_{12} was at par with T_6, T_8 and T_{13} at new emergence shoot stage; with T_6, T_8, T_{10} and T_{13} at flowering stage; with T_6, T_{10} and T_{13} at nut setting stage and at harvest stage. The lowest available phosphorus was observed with the absolute control (treatment T_1) where fertilizers were not applied.

Further, the available P_2O_5 content of soil irrespective of treatments gradually declined in all the treatment from new emergence stage to harvesting stage, it may be due to the uptake of P_2O_5 by plants which usually takes place intensively after flowering (Barbatzki 1959). Further, organic matter mineralization provides a continuous, although limited, supply of plant available P (Tisdale *et al*. 1995) [14].

Increase in available P_2O_5 content of soil could be observed due to the application of NPK levels alone or with soil and foliar application of boron through borax and zinc through and zinc sulphate at all stages of fruit development over the absolute control or no fertilizer application (treatment T_1). The increase in phosphorus availability might be also due to synergistic effect of N with phosphorus and potassium which increased the availability of P in the soil (Shrivastava 2002) [12].

In general, the data indicated that the soil having high organic matter content showed high available P. This increase in organic matter with foliar spray treatment might be due to accumulation of litter fall during fruit development period as the numbers of leaves were enhanced with foliar spray over the control.

Significantly highest available potassium i.e. 391.06 kg ha^{-1} at new emergence shoot stage, 356.42 kg ha^{-1} at flowering stage, 294.13 kg ha^{-1} at nut setting shoot stage and 260.71 kg ha^{-1} at harvest stage, was observed in treatment T_9 i.e. 2.0:1.0:1.0 kg NPK + soil application of boron though borax @ 50g + zinc through zinc sulphate @ 125g/tree; where treatment T_9 was significantly superior over all the treatments. The lowest available potassium was observed with the absolute control (treatment T_1) where fertilizers were not applied. The increase in potassium availability might be also due to synergistic effect of N with phosphorus and potassium which increased the availability of K in the soil (Shrivastava 2002) [12]. In addition to this, Varalakshmi *et al*. (2005) [15] reported that the higher availability of potassium in the treatment of package of practice where along with NPK fertilizers and 40 kg per tree FYM was applied might be due to the beneficial effect of application of FYM along with inorganic fertilizer. It may be

ascribed to the reduction of K fixation and release of K due to the interaction of organic matter with clay besides the direct addition of potassium to available pool of the soil (Tandon 1987). According to Tisdale *et al*. (1995) [14], organic matter improves CEC, which reduces potential leaching losses of element such as K^+, Ca^{2+} and Mg^{2+} and increase its availability. Balaguraiah *et al*. (2005) reported significant increase in soil available K due to organic matter application.
The increase in available K in the soil may, probably, due to the fact that solubility of K is dependent on wetting and drying regimes which behaves in soils (Kanwar 1976). In some soils, non-exchangeable K becomes available as the exchangeable and solution K^+ are removed by cropping or lost by leaching (Tisdale *et al*. 1995) [14].

Micronutrients status of soil

Significantly highest available Fe i.e. 61.21 mg kg^{-1} at new emergence shoot stage, 51.43 mg kg^{-1} at nut setting stage and 54.25 mg kg^{-1} at harvest stage and numerically available Fe 56.06 mg kg^{-1} at flowering stage was observed in treatment T_{11} i.e. 1.0**:**0.50**:**0.50 kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; where treatment T_{11} was at par with T_6 and T_{12} at new emergence shoot stage; with T_7, T_9, T_{10} and T_{12} at nut setting stage and with T_5 at harvest stage.
Regarding high availability of Fe in acid lateritic soils, Katyal *et al*. (1982) [7] cleared that the high content of available Fe may be due to accumulation of sesquioxides and also higher organic matter content, which keeps iron in complexes and available form. In addition to this, Tisdale *et al*. (1995) [14] explained that when a strong acid anion (NO_3^-) is absorbed and replaced with a weak acid (HCO_3^-), the pH of root zone increases, particularly in low buffered systems, which decreases Fe availability. Thus, Fe solubility and availability are favored by the acidity that develops when NH_4^+ is utilized by plants.
Significantly highest available Mn i.e. 33.54 mg kg^{-1} at new emergence shoot stage, 68.23 mg kg^{-1} at flowering stage, 68.39 mg kg^{-1} at nut setting stage and 58.23 mg kg^{-1} at harvest stage was observed in treatment T_{13} i.e. 2.0**:**1.0**:**1.0 kg NPK kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; where treatment T_{13} was significantly superior over all the treatments and followed by T_{10} at new emergence shoot. Treatment T_{13} was at par with T_3, T_{10} and T_{11} at flowering stage; with T_8 and T_{11} at nut setting stage and with T_6 and T_{12} at harvest stage.
Regarding high availability of Mn in acid lateritic soils, Mehta and Patel (1967) [8] stated that the high concentration of available Mn might be due to decomposition and mineralization of organic matter due to warm and humid climate of the region.
Significantly highest available Zn i.e. 0.69 mg kg^{-1} at new emergence shoot stage, 0.60 mg kg^{-1} at flowering stage, 0.56 mg kg^{-1} at nut setting stage and 0.56 mg kg^{-1} at harvest stage was observed in treatment T_{10} which was at par with T_2, T_3, T_6, T_8, T_9, T_{12} and T_{13} at new emergence shoot stage; significantly superior over all the treatments except T_{12} at flowering stage, at par with T_3 and T_9 at nut setting stage and found to be significantly superior at harvest stage.
It could be seen from the data that the Zn content in soil decreased from new emergence shoot stage to harvest stage, which may be attributed to the fact that the availability of Zn^{2+} decreases with increased soil pH (Tisdale *et al*. 1995) [14]. Further, Tisdale *et al*. (1995) [14] explained that high P availability can induce Zn deficiency. In this context, Tisdale *et al*. (1995) cleared that increasing soil temperature increases the availability of Zn to crops by increasing solubility and diffusion of Zn^{2+}.
Significantly highest available Cu i.e. 4.29 mg kg^{-1} at new emergence shoot stage and 2.68 mg kg^{-1} at harvest stage, while numerically highest available Cu i.e. 2.81 mg kg^{-1} at flowering stage and 2.59 mg kg^{-1} at nut setting stage was observed in treatment T_{12} i.e. 1.5**:**0.75**:**0.75 kg NPK + spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5%; The treatment T_{12} was at par with T_{10} at new emergence shoot stage while the treatment T_{11} and T_{13} were found to be at par with T_{12} at harvest stage.
Significantly highest hot water soluble B i.e. 0.28 mg kg^{-1} at new emergence shoot stage, 0.30 mg kg^{-1} at new emergence shoot stage, 0.28 mg kg^{-1} at nut setting stage and 0.33 mg kg^{-1} at harvest stage was observed in treatment T_8 i.e. 1.5**:**0.75**:**0.75 kg NPK + soil application of boron though borax @ 50g + zinc through zinc sulphate @ 125g / tree; where treatment T_8 was at par with T_{13} at new emergence shoot stage; treatment T_8 was significantly superior over all the treatments followed by T_{12}; and treatment T_8 was at par with T_{12} at nut setting stage and harvesting stage.
No specific trend of increase or decrease of hot water soluble B at different growth stages of cashew (*i.e.* at new emergence shoot stage, flowering stage, nut setting stage and at harvest) was observed with the application of different levels of inorganic fertilizers with soil and foliar application of Zn and B. By and large, hot water soluble B decreased from new emergence shoot stage to nut setting stage and thereafter increased at harvesting stage. Similar initial decrease of hot water soluble B from 30 days after sowing to 90 days after sowing of okra and thereafter increase in hot water soluble B at harvest of the crop in lateritic soils of Konkan was reported by Kadam (2016).

Conclusion

By considering the higher yield of cashew nut, chemical properties of soil and availability of nutrients in the soil, application 1.0:0.50:0.50 kg NPK per tree along with spraying of foliar application of boron though borax @ 0.25% + zinc through zinc sulphate @ 0.5% was to be beneficial in lateritic soils of Konkan.

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