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Effect of NPK levels on the physico-chemical properties and available nutrient status under cluster bean in lateritic soils of Konkan (M.S.)

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Abstract
A field experiment was conducted during Rabi, 2020-21 entitled, "Studies on different forms of potassium under cluster bean (*Cyamopsis tetragonoloba* (L.) Taub**)** as influenced by the application of different levels of NPK in lateritic soils of Konkan" at Dapoli. Different levels of nitrogen (20, 40, 60 kg ha^{-1}), phosphorous (40, 60 kg ha^{-1}), Potassium (40, 60 kg ha^{-1}) and an absolute control was used to comprise nine treatment combinations which were replicated thrice and analyzed using randomized block design. The chemical properties *viz*., Soil reaction, Electrical conductivity and Organic carbon at flowering content of soil did not show a significant change in their status. However, organic carbon at harvest, available macronutrients (N, P, K,) showed significant improvement as a consequence of various treatment combinations. In general, chemical properties of experimental plot represented a typical lateritic soil of Konkan (M.S.). Significantly highest available nitrogen, phosphorous and potassium content was recorded under treatment receiving highest level of inorganic fertilizers along with FYM application. Further, a stage wise decrease in nutrient status was observed from flowering to harvest of cluster bean.

Keywords: Chemical properties, available nutrients, cluster bean, lateritic soils

Introduction
The inherent capacity of soils to provide nutrients in optimum levels for crop growth is nothing but soil fertility which is generally denoted by analyzing available nutrient status of soils. Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.) popularly known as its vernacular name 'Guar' has come to be recognized as one of the most important commercial crop of arid and semi-arid region. Gillete (1958) reported 'Tropical Africa' as its center of origin. Cluster bean grown for different purposes *viz*., vegetable, green fodder, green manuring, production of seed and for endospermic gum. Besides all these, it provides concentrate and fodder for cattle and adds to the fertility of soil by fixing considerable amount of atmospheric nitrogen. It is a drought hardy leguminous crop because of its deep tap root system and has high capacity to recover from water stress. Traditionally, pods of cluster bean are used for vegetable purpose. In India, cluster bean is grown on an area of 23.30 lakh hectare with a productivity of 428.0 kg per hectare of pods. The maximum contribution in respect of area is shared by Rajasthan (18.18 lakh ha), followed by Gujarat (2.27 lakh ha), Haryana (1.27 lakh ha) and Punjab (0.14 lakh ha) with a production of 19.85 lakh tonnes, 2.27 lakh tonnes, 1.20 lakh tonnes and 0.14 lakh tonnes respectively (Anonymous., 2013) [1]. Rajasthan alone comprises about 78 percent of area and contributes 80 percent of production to the national basket of guar. The lateritic soils of Konkan region are generally sandy clay loam in texture, moderately acidic in nature having pH between 5.0- 6.0, highly base leached and sesqui-oxide rich soils due to high rainfall, having organic carbon content from 1 to 2 percent, favours production of leguminous crop. The chemical parameters of soil such as pH and EC are important prerequisites that affects nutrient availability as well as growth of the plant. The soils with pH ranging between 6.5 to 7.5 are considered ideal for availability of maximum nutrients. Electrical conductivity denoted soluble salt content of soils whose higher levels adversely affects nutrient uptake and even water uptake by roots. Nitrogen is a major nutrient for living organisms on earth and plays a central role in regulating the composition, structure and functions of ecosystems (Fang *et al*., 2009) [4]. Phosphorous ranks second most essential nutrient after nitrogen and plays a vital role in plant growth.

Being part of adenosine triphosphate, adenosine diphosphate it takes part in energy transformation in plant cells and acts as energy currency. Potassium helps in maintaining quality of product. For supply of all these macronutrients optimum applications of fertilizers is necessary to reduce toxicity hazards and financial losses.

Material and Methods

The field experiment for proposed study was conducted in Rabi 2021 at Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri. Dapoli is located in the tropical zone at 17° 45' N latitude and 73° 11' E longitude. The city is at an elevation of 800 feet (244 metres) and is 8 kilometres from the Arabian Sea. It has a hot and humid climate with three distinct seasons: summer (March to May), rainy (June to October), and winter (November to February). The region receives a large amount of rain (above 3000 mm, annually). The experiment was laid out in Randomised block design comprising 9 treatments receiving different levels of nitrogen (80, 100, 120 kg ha^{-1}), phosphorous (40, 60, 80 kg ha^{-1}) and levels of potassium (100 kg ha^{-1}) and an absolute control were replicated thrice in randomized block design given in Table 1. The initial physio-chemical properties of soils are presented in Table 2. The soil sampling was done at different growth stages of cluster bean i.e., flowering and at harvest stage. The samples were prepared for analysis by shade drying and sieving through 2 mm sieve. The data was statistically analyzed to calculate standard error and cumulative difference.

Table 1: Details of the treatments

Tr. No.	Description of Treatment
T_1	Absolute control (No Fertilizers)
T_2	20:40:00N:P_2O_5:K_2O kg ha^{-1}
T_3	20:40:40N:P_2O_5:K_2O kg ha^{-1}
T_4	40:40:40N:P_2O_5:K_2O kg ha^{-1}
T_5	40:40:60N:P_2O_5:K_2O kg ha^{-1}
T_6	40:60:40N:P_2O_5:K_2O kg ha^{-1}
T_7	40:60:60N:P_2O_5:K_2O kg ha^{-1}
T_8	60:40:40N:P_2O_5:K_2O kg ha^{-1}
T_9	60:40:60N:P_2O_5:K_2O kg ha^{-1}

Soil was found to have strongly acidic pH, and having normal electrical conductivity, high in organic carbon, low in available nitrogen and very low and moderately high in available phosphorus and available potassium, respectively. The pH and electrical conductivity in soil were determined potentiometrically and conduct metrically as per the procedure given by Jackson (1973) [8] while, the organic carbon was determined by Walkley and Black's wet digestion method as described by Black (1965) [5]. The available nitrogen was determined by alkaline permanganate (0.32% $KMnO_4$) method as explained by Subbiah and Asija (1956) [15], while available phosphorus was determined by Brays No. 1 method given by Bray and Kurtz (1945) [6]. Potassium in soil was determined with the help of flame photometer by extracting sample using neutral normal ammonium acetate. The data obtained were subjected to statistical analysis by following procedure pertinent to "Randomized Block Design" as given by Panse and Sukhatme (1967) [11].

Results and Discussion

Initial physico-chemical properties of the soil

Initial

Table 2: Initial physico-chemical properties of the soil

Property		Content
Chemical Properties		
I)	pH (1:2.5)	5.52
II)	Electrical conductivity (dS m^{-1})	0.12
III)	Organic Carbon (g kg^{-1})	8.85
IV)	Available N (kg ha^{-1})	198.48
V)	Available P_2O_5 (kg ha^{-1})	8.40
VI)	Available K_2O (kg ha^{-1})	183.85

Periodical changes in physico-chemical properties of the soil

pH (soil reaction)

The soil pH at various observational periods ranged from 5.25 to 5.36 at flowering, and 5.34 to 5.44 at harvest stage (Table 3). The pH of lateritic soils of Konkan region ranged from 4.75 to 6.50 (Anonymous 1990) [1]. The data indicated that the soils are acidic in nature. The acidic nature of the soils might be attributed to leaching of the soluble salts due to heavy precipitation.

The data of soil pH at flowering as well as at harvest revealed that the application of different doses of NPK did not influence significantly on pH of the soil. Numerically treatment T_3 *i.e.* 20:40:40 NPK kg ha^{-1} and recorded the highest soil pH value at flowering (5.36) and at harvest stage (5.44). Non-significant influence of different levels of NPK on soil pH was also noted by Bhuvad (2021) [4] in lateritic soils of Konkan.

Electrical conductivity

The data related to electrical conductivity of the soil as influenced by different doses of NPK ranged from 0.136 to 0.195 ds m^{-1} at flowering and 0.070 to 0.120 ds m^{-1} at harvest stage (Table 3). In general, lateritic soils are free from soluble salt due to high rainfall (Anonymous, 1990) [1]. Electrical conductivity of acid soils found in Konkan region indicated that the soils are free of soluble salts, which might be attributed to the leaching of soluble salts due to heavy precipitation.

The perusal of the data indicated that the application of different doses of NPK did not influence significantly on EC of the soil at various observational periods. Numerically treatment T_7 i.e. 60:40:40 NPK kg ha^{-1} recorded the highest soil EC value 0.195 ds m^{-1} at Flowering, while T_8 *i.e.* 60:40:40 NPK kg ha^{-1} recorded the highest soil EC value 0.120 ds m^{-1} at harvest stage.

The increase in EC with the application of different doses of NPK along with FYM @ 10 t ha^{-1} during the study period might be due to possible build-up of the soluble nutrients drawn from manure on mineralization. In general, the electric conductivity of the soil decreased at harvest of the crop over the flowering irrespective of the treatments. This decrease may, probably, be due to partial washing away of the salts from the surface soil, besides uptake of the minerals by the plants.

Organic carbon content

The data pertaining to the organic carbon of the soil as influenced by different doses of NPK ranged from 10.32 to

11.53 g kg^{-1} at flowering and 10.47 to 12.44 g kg^{-1} at harvest (Table 3). The ranges indicated that organic carbon in soil is "very high" as per the ranges proposed by Banger and Zende (1978) [2]. These figures are in conformity with reported earlier (Anonymous, 1990 and Bhuvad, 2021) [1, 4]. In general, the very high organic carbon content of the soils might be attributed to the humid climate of the Konkan region (Anonymous, 1990) [1].

Table 3: Effect of different cultivation practices and various crops on periodical changes in the soil reaction (pH)

Tr. Code	Treatment	pH (1:2.5)		EC (dS m^{-1})		Organic carbon (g kg^{-1})	
		At Flowering	At harvest	At Flowering	At harvest	At Flowering	At harvest
T_1	00:00:00 NPK kg ha^{-1}	5.25	5.34	0.136	0.070	10.32	10.47
T_2	20:40:00 NPK kg ha^{-1}	5.31	5.33	0.145	0.072	10.45	11.32
T_3	20:40:40 NPK kg ha^{-1}	5.36	5.44	0.152	0.076	11.04	12.42
T_4	40:40:40 NPK kg ha^{-1}	5.34	5.37	0.156	0.071	11.20	12.07
T_5	40:40:60 NPK kg ha^{-1}	5.27	5.32	0.161	0.086	11.32	12.39
T_6	40:60:40 NPK kg ha^{-1}	5.30	5.34	0.150	0.084	11.45	11.47
T_7	40:60:60 NPK kg ha^{-1}	5.27	5.25	0.195	0.107	11.53	12.44
T_8	60:40:40 NPK kg ha^{-1}	5.34	5.35	0.132	0.120	11.45	11.85
T_9	60:40:60 NPK kg ha^{-1}	5.25	5.36	0.178	0.105	11.16	11.94
S.E(m) ±		0.047	0.05	0.01	0.02	0.27	0.28
CD @ 5%		NS	NS	NS	NS	NS	0.85

The data of soil organic carbon revealed that the application of different doses of NPK at flowering did not influence significantly on organic carbon content of the soil at flowering stage, but found to be significant at harvest. At harvest, the highest organic carbon (12.44 g kg^{-1}) was recorded in treatment T_7 (60:40:60 NPK kg ha^{-1}); where treatment T_7 was at par with treatment T_3, T_4, T_5, T_8, T_9. The lowest organic carbon at harvest was recorded in control (T_1).

Close scrutiny of the data indicated that the organic carbon of the soil increased at harvest of the crop over to flowering stage irrespective of the treatments. This increase may, probably, be due to the soil enrichment in organic carbon content could be reason of several factors such as addition of litter fall, fine root biomass recycled and root exudates and its reduced oxidation of organic matter. Kare fog (2008) [10] reported that N added to decomposing organic matter often has no effect or a negative effect on microbial activity, at least in the long term. The negative effect of N is mainly found with recalcitrant organic matter with a high C/N ratio, whereas a positive effect of N is common for easily degradable organic material with low C/N ratio. The negative effect of N could be explained by: (i) N disturbs the outcome of competition between its potent (ii) through 'ammonia metabolite repression', N blocks production of certain enzymes, at least in basidiomycetes, and enhances breakdown of the most available cellulose, whereby recalcitrant lignocellulose accumulates; (iii) amino compounds condense with polyphenols and other decomposition products, forming 'browning precursors' which are toxic or inhibitory. The effect of adding N may depend on the microflora present. There are indications that some microorganisms have a 'luxury uptake' of N when it is present in sufficient amounts, thereby delaying N mineralization. The addition of N seems to increase the formation of water-soluble, brown, recalcitrant compounds, but to decrease the amount of humus formed.

Nutrient status

Available Nitrogen (kg ha^{-1})

Available nitrogen content in soil was significantly affected due to the application of different doses of NPK and varied from 226.19 to 306.94 kg ha^{-1} at flowering stage and 207.77 to 265.52 kg ha^{-1} at harvest stage (Table 4) indicating fertility rating from 'low to mediun' Banger and Zende, 1978) [2]. The available nitrogen content in lateritic soil ranges from low to moderately high and the value vary between 149.0 to 674.0 kg ha^{-1} (Anonymous, 1990) [1]. In the present investigation, cluster bean being a legume is able to meet much of its nitrogen needs from atmospheric nitrogen through symbiotic relationship with bacteria.

Perusal of data indicated that the application of different doses of NPK significantly (from treatment T_2 to T_9) increases available nitrogen over absolute control (T_1). Increase in available nitrogen with fertilizer application might be attributed to the direct addition of nitrogen through fertilizer to the available pool of the soil. In this regards, Sheeba and Chellamuthu (1999) [13] ascribed such build up in the available N status of the soil value to mineralization of N from added FYM. The increase in available N status of the soil with combined use of fertilizers and organic manures may be explained in terms of their residual effect and build up in organic N fractions of the soil due to biochemical degradation and mineralization.

Application of 60:40:40 NPK kg ha^{-1} (T_8) at flowering stage and 60:40:60 NPK kg ha^{-1} (T_9) at harvest recorded the significantly highest available nitrogen to the tune of 306.94 kg ha^{-1} and 265.52 kg ha^{-1}, respectively. The treatment T_8 was found to be at par with T_7 and T_8 at flowering and treatment T_9 was found to be at par with T_8 at harvest of the crop. The lowest values of available nitrogen i.e. 226.19 kg ha^{-1} at Flowering and 207.77 kg ha^{-1} at harvest was observed in control in treatment (T_1) which may be due to the cultivation of crop without any addition of fertilizer, causing reduction in the available N status of the soil.

Further, data showed that the available nitrogen from soil decreased with advancement of crop growth from flowering to harvest of the crop. This decrease may be attributed to the fact that lateritic soils are percolative in nature and there was probable N losses due to leaching and denitrification under field conditions, besides uptake by plants. Similar trends of decrease of nitrogen in lateritic soil was also reported by Bhuvad (2021) [4].

Available Phosphorus (P_2O_5) (kg ha^{-1})

Available phosphorus from the soil was significantly affected due to application of different doses of NPK and varied from 9.13 to 13.64 kg ha^{-1} at Flowering and 8.92 to 11.50 kg ha^{-1} at harvest stage (Table 4). The available P_2O_5 content in lateritic soils ranged from 0.35 to 74.14 kg ha^{-1} with an average of 14.14 kg ha^{-1} (Anonymous, 1990) [1].

Table 4: Available N, P_2O_5 and K_2O at different growth stages of cluster bean as influenced by different levels of NPK

Tr. Code	Treatment	Available N		Available P_2O_5		Available K_2O	
		(kg ha^{-1})					
		At flowering	At harvest	At flowering	At harvest	At flowering	At harvest
T_1	00:00:00 NPK kg ha^{-1}	226.19	207.77	9.13	8.92	187.66	150.40
T_2	20:40:00 NPK kg ha^{-1}	243.09	223.86	11.01	10.13	198.03	153.32
T_3	20:40:40 NPK kg ha^{-1}	256.48	228.09	10.84	10.34	236.40	188.80
T_4	40:40:40 NPK kg ha^{-1}	259.32	234.18	12.56	10.48	238.48	199.91
T_5	40:40:60 NPK kg ha^{-1}	262.62	238.99	12.65	10.53	263.88	226.84
T_6	40:60:40 NPK kg ha^{-1}	264.28	237.74	13.40	10.75	232.41	190.75
T_7	40:60:60 NPK kg ha^{-1}	297.16	254.54	13.64	11.50	281.02	243.86
T_8	60:40:40 NPK kg ha^{-1}	306.94	261.62	12.90	10.51	233.23	194.30
T_9	60:40:60 NPK kg ha^{-1}	300.73	265.52	12.65	10.69	274.05	235.08
S.E(m) ±		13.48	3.83	0.44	0.42	10.55	9.40
CD @ 5%		40.42	11.47	1.33	1.25	31.63	28.19

Application of different doses of NPK significantly increases available phosphorus over the absolute control. Increase in available phosphorus with fertilizer application might be attributed to the direct addition of phosphorus through fertilizer to the available pool of the soil. Further, the increase in phosphorus availability might be also due to synergistic effect of N with phosphorus which increased the availability of P in the soil (Shrivastava, 2002) [14]. Moreover, organic matter mineralization provides a continuous, although limited, supply of plant available P (Tisdale *et al*. 1995) [17]. In this context, Tandon (1987) [16] opined that the increase in available P due to addition of organic matter may be ascribed to the decomposition of organic matter, accompanied by the release of appreciable quantities of CO_2 which when dissolves in water, forms carbonic acid, which is capable of decomposing and dissolving certain primary minerals. The organic matter also forms a cover on sesqui-oxides and makes them inactive and thus reduces the phosphate fixing capacity of the soil, which ultimately, helps in the release of ample quantity of phosphorus. Application of 40:60:60 NPK kg ha^{-1} (T_7) at flowering and at harvest registered the significantly highest available phosphorus (13.64 kg ha^{-1} and 11.50 kg ha^{-1}, respectively). However, treatment T_7 was found to be at par with T_4, T_5, T_6, T_8 and T_9 at flowering and was at par with T_3, T_4, T_5, T_6, T_8 and T_9 at harvest of the crop. The lowest values of available phosphorus i.e. 9.13 kg ha^{-1} at flowering and 8.92 kg ha^{-1} at harvest was observed in control treatment (T_1), which may be due to the cultivation of cluster bean crops without any addition of fertilizer, causing reduction in the available P status of the soil.

Though 40 or 60 kg ha^{-1} of P_2O_5 was added at the time of sowing as a basal dose, the soil P_2O_5 content was only to the tune of 8.92 to 13.64 kg ha^{-1}. This indicated most of the applied phosphorus has been fixed in the soil and is not available to the plants. The lateritic soils have high phosphorus fixing capacity (91%) (Kadrekar and Talashilkar, 1977) [9]. Phonde (1987) [12] reported it to be 95 percent. Further, the available P2O5 content of soil irrespective of treatments gradually declined in all the treatment at crop maturity, it may be due to the uptake of P2O5 by plants which usually takes place intensively after flowering (Barbatzkii, 1959) [3].

Available Potassium (K_2O) (kg ha^{-1})

Available potassium content in the soil was significantly affected due to application of different doses of NPK and varied from 187.66 to 281.02 kg ha^{-1} at flowering and 150.40 to 243.86 kg ha^{-1} at harvest stage (Table 4) indicating fertility rating from 'low to high' (Bangar and Zende, 1978) [2]. The available K_2O content in lateritic soils ranges from 11.00 to 1152.00 kg ha^{-1} with an average of 226.00 kg ha^{-1} (Anonymous, 1990) [1].

Application of different doses of NPK significantly increased available potassium over the absolute control. Increase in available potassium with fertilizer application might be attributed to the direct addition of potassium through fertilizer to the available pool of the soil. The increased in potassium availability also might be due to synergistic effect of N with potassium which increased the availability of K in the soil (Shrivastava, 2002) [14].

Significantly highest available potassium i.e. 281.02 kg ha^{-1} at flowering and 243.86 kg ha^{-1} at harvest stage was recorded in treatment T_7 i.e. 40:60:60 NPK kg ha^{-1} which was found to be at par with the treatment T_5, and T_9 at flowering and at harvest of the crop. The lowest values of available potassium i.e. 187.66 kg ha^{-1} at flowering and 150.40 kg ha^{-1} at harvest was observed in control in treatment (T_1), which may be due to the cultivation of cluster bean crops without any addition of fertilizer, causing reduction in the available K status of the soil.

Further, the available K content of soil irrespective of treatments gradually declined in all the treatment at crop maturity. This decrease in K content may probably attribute to leaching of soluble K fractions and removal of solutions K^+ by crop (Tisdale *et al.*, 1995) [17].

Conclusion

It can be concluded from the above results that; the Application of 40:60:60 N:P:K kg ha^{-1} dose significantly improve physico-chemical properties and also available nutrient status of the soil. In case of soil pH, electrical conductivity and organic carbon content at flowering the non-significant results were recorded with the application of different levels of NPK.

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