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Research paper

Impact of mulching and nutrient management under pulses based cropping systems on vertisols of southern transitional zone of Karnataka

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ABSTRACT

A field experiment was conducted to study the effect of mulching and nutrient management under different pulse based cropping system during 2018-19 at Indian Institute Pulses Research, Regional Research Station, Dharwad, Karnataka, India. The field experiment was conducted in deep black soil using split-split plot design with three replications. The treatments comprised of four cropping systems *i.e.*, maize-chickpea, soybean-chickpea, groundnut-chickpea and mungbean-sorghum and two levels of fertilisation (farmers practise and recommended rate of fertilisers) with mulching and without mulching. The pooled yield of different crops under cropping system was significantly higher with mulching and recommended rate of fertilizer application. Among the different cropping systems, maize-chickpea was recorded significantly higher chickpea equivalent yield (3867 kg/ha) compared to other cropping system. Application of recommended rate of fertilizers resulted in higher chickpea equivalent yield of 2794 kg/ha over farmers' practice. Among the mulching practices, mulching with crop residues recorded significantly higher chickpea equivalent yield of 4257 kg/ha over no mulching (3754 kg/ha). Higher yields of component crops are reported in recommended rate of fertilisers with mulching. Hence, for realising higher system productivity and net returns, it is better to grow maize during *kharif* season followed by chickpea in *rabi* season with recommended rate of fertilisers and crop residue mulching for *in-situ* moisture conservation.

Key words: Chickpea equivalent yield, Cropping systems, Mulching, Nutrient management

INTRODUCTION

Pulses are rich source of proteins, minerals and essential vitamins and preferred as an important constituent of vegetarian diet in India. Pulses based cropping system plays a significant role in understanding complex interaction which involves plant, soil and management practices and their interaction effect on system productivity and soil physical and chemical properties (Kumar *et al*., 2018). Inclusion of cereal-legume crop rotation with recommended rate of fertilizer application are essential for sustaining crop productivity and maintaining soil health (Hazra and Bohra, 2021; Meena *et al*., 2019). Majority of farmers commonly practice cereal-cereal based cropping systems. Most of cereals are being nutrient exhaustive crops resulting in reducing the soil fertility and productivity and sustainability of the cropping system. Pulses are known for their inherent capability of fixing atmospheric nitrogen into the soil. Therefore, inclusion of pulses in cropping systems will improve the productivity on sustainable basis. Pulses improve the soil physical, chemical and biological properties (Hazra *et al*., 2018; Kumar *et al*., 2018). Inclusion of different pulses will add in the breaking soil borne pest and disease cycles, thereby reducing the population of crop associated weeds and finally the soil erosion and depletion. More importantly pulses fix atmospheric nitrogen into the soil through effective root nodules.

Pulses are important constituent of Indian diet after cereals. In India, productivity of pulses is lower when compared to the average productivity in the world (Dotaniya *et al*., 2022; Hazra *et al*., 2018; Kumar *et al*., 2020). It is mainly attributed to their cultivation on marginal lands having low soil fertility under rainfed conditions, non-judicious application of fertilizers and reduced use of organic fertilizers thus resulting in poor soil physical and chemical properties. To overcome these problems, adopting improved crop management practices such as rainwater conservation practices along with application of recommended rate of fertilizers and improved cropping systems are necessary to increase the productivity on sustainable basis (Ghosh *et al*., 2014; Kumar *et al*., 2018; Prabhakar *et al*., 2022). Despite increase in production, India is the largest importer of pulses. To meet the growing demand of pulses and to achieve the twin targets of increase in area and production of pulse crops, the suitable approach is to go in for intensive cultivation with improved cropping systems mode by following suitable soil moisture conservation measures like mulching with application of recommended rate of fertilizers. Mulching improves crop productivity through conservation of *in situ* soil moisture (Basavaneppa *et al.*, 2017; Kumar *et al.*, 2006; Maurya *et al.*, 2020). Therefore, a field experiment was conducted on the effect of pulses based cropping systems, fertilizer management and mulching on system productivity, nutrient use efficiency and soil properties in the *Vertisols* of Dharwad, Karnataka, India.

MATERIALS AND METHODS

Soil characteristics

A field experiment with four pulse-based cropping systems was carried during 2018-19 at ICAR-Indian Institute Pulses Research, Regional Research Station, Dharwad, situated in northern transitional zone of Karnataka, India. The soil of the experimental site was black soil belonging to soil taxonomic classification of Vertisol (*Typic haplusterts*) with alkaline in reaction (pH 7.9) and electrical conductivity 0.12 dS/m with bulk density 1.31 Mg/m^3 and water holding capacity of 61.5%. Soils were medium in organic carbon content (4.0 to 5.4 g/kg), low in available N (218 kg/ha), and medium in available P and K contents (14.4 and 150 kg/ha, respectively).

Treatment details and soil nutrient analysis

The experiment was laid out with sixteen treatments in split- split plot design with three replications. Cropping systems were assigned as main plots, and fertilizer application and soil conservation practices (mulching) were the sub-plot factors. Main factors consisted of 4 different cropping systems *i.e.,* maize-chickpea (M-C), soybean-chickpea (Sb-C), groundnut-chickpea (Gn-C) and mungbean-sorghum (Mb-S). Sub plots include fertilizer application *i.e.,* recommended rate of fertilizer (RRF) and farmers' practice (FP), and soil conservation practices include mulching and without mulching. Interpretation of the data was carried out in accordance with report of Meena *et al*. (2019). The critical difference values were calculated wherever the 'F' test values were significant. Chickpea equivalent yield (CEY) was computed by converting the companion crops yield into the yield of main crop based on prevailing market price as mentioned by Uddin *et al*. (2009) and soil nutrients analysis were carried out as described by Singh *et al*. (2005).

RESULTS AND DISCUSSION

Crop yields and system productivity

The results revealed that grain yield of different component crops was significantly influenced by conservation practises (mulching) with nutrient management. The mean grain yield of *kharif* crops viz., mungbean, maize, groundnut and soybean under different practises ranged from 1040-1400, 2711-3583, 1414-1903 and 1160-1708 kg/ha, respectively. The mean grain yield of *rabi* crops i.e., chickpea and sorghum ranged from 1630-1846 kg/ha and 1494-2620 kg /ha, respectively. Higher levels of grain yields were recorded in component crops with recommended rate of fertilisers with mulching in both *kharif a*nd *rabi* crops. Among the four cropping systems, maize-chickpea cropping system recorded higher chickpea equivalent yield of 3867 kg/ha followed by groundnut-chickpea (2460 kg/ha). Lower chickpea equivalent yield was recorded in mungbean-sorghum (2169 kg/ha) and soyabean-chickpea (2313 kg/ha) cropping systems (Table 1). Mulching produced 17% higher chickpea equivalent yield. It is attributed to residual higher soil nutrient availability after the harvest of chickpea thus resulting in higher nutrient uptake by the crop with greater crop yields and higher market rates for maize and chickpea crops. Integration of pulse crop improved the soil physical, chemical and biological properties of the soil. Similarly, earlier study also reported that conservation practises (mulching) and recommended rate of fertilisers significantly increased the yield of chickpea and maize over the conventional practises (Basavaneppa *et al*., 2017; Kumar *et al*., 2006). Meena *et al*. (2019) observed that greengram yield was significantly higher in maize-chickpea-greengram and maize-mustard-greengram systems with conservation practises. The beneficial effect of pulses was more pronounced in maize as compared to sorghum after chickpea and pigeonpea (Singh *et al*., 2009). Among the two mulching practices, mulching with crop residue recorded significantly higher chickpea equivalent yield of 4257 kg/ha over no mulching (3415 kg/ha). Application of recommended rate of fertilizer (RRF) recorded significantly higher chickpea equivalent yield of 4250 kg/ha over farmers' practice (3714 kg/ha). The application of recommended rate of fertilisers resulted in increased availability of nutrients in the soil and higher uptake of nutrients by the crop. This finally resulted in increased crop yields over farmers practise. Pulses being a rich source of protein source, they are also important for sustaining crop yields, enriching the soil through biological nitrogen fixation. Inclusion of pulse crops maintains soil health and sustains the crop yields under different cropping systems (Kumar *et al*., 2018). Introduction of pulses in cereal-cereal based cropping systems leads to the sustainability of these systems by ensuring both nitrogen economy and improved soil health. An estimated amount of 30 to 147 kg/ha nitrogen is fixed by different pulse crops in the soils. The beneficial effect of pulse crops in improving soil health and sustaining productivity has long been realized (Venkatesh *et al*., 2013; Kumar *et al*., 2019). On account of biological nitrogen fixation, addition of considerable amount of organic matter through root biomass and leaf fall, deep root systems, mobilization of nutrients, protection of soil against erosion and improving microbial biomass. An ideal cropping system should use natural resources efficiently, provide stable and high returns and do not damage the ecological balance. The beneficial effect of pulses was more pronounced in maize as compared to sorghum after chickpea and pigeonpea (Kumar *et al.,* 2018; Ghosh *et al*., 2014).

Nutrients uptake and soil nutrients status

The nutrient uptake data revealed that uptake of N, P, K and S by different cropping system were significantly higher with adoption of conservation practices and application of recommended rate of

Table 1. System productivity (chickpea equivalent yield, kg/ha) in different cropping systems

Cropping system	*Cs-A		*Cn-A		
	*FP	*RP	FP	RP	Mean
Maize-chickpea	4000	4257	3457	3754	3867
Soybean-chickpea	2528	2727	1963	2033	2313
Groundnut-chickpea	2474	2775	2234	2358	2460
Mungbean-sorghum	2324	2359	1905	2088	2169
CD (p=0.05)	301	320	248	216	266

*FP: Farmer practice; RP: Recommended practice; Cs-A: Conservation practices (Mulching) + Nutrient management; Cn-A-Conventional practices (Without mulching) + Nutrient management

Table 2. Nutrients uptake (kg/ha) as influenced by cropping systems and management practices

Cropping system	Nitrogen		Phosphorus		Potash		Sulphur	
	RP	FP	RP	RP	RP	FP	RP	FP
Maize-chickpea	95.0	92.4	14.2	12.1	16.9	15	14.2	12.7
Soyabean-chickpea	74.0	70.6	8.3	7.1	10.8	9.9	6.8	6.0
Groundnut-chickpea	110.1	88.5	6.4	6.1	13.7	11.6	7.7	6.5
Mungbean-sorghum	81.1	71.7	8.4	5.5	17.9	5.5	9.5	8.2
CD (p=0.05)	3.9	1.8	0.3	0.3	0.4	0.3	0.4	0.3

*FP: Farmer practice; RP: Recommended practice

Table 3. Mean soil nutrient availability after harvest of *rabi* crops

Cropping system	Available nutrient (kg/ha)			
	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. S
Maize-chickpea	272	19	194	12
Soyabean-chickpea	265	17	183	12
Groundnut-chickpea	282	18	184	13
Mungbean-sorghum	285	19	177	14
CD (p=0.05)	9	1.6	8	1

fertilisers. The higher nutrients uptake was recorded in maize-chickpea cropping system with mulching and application of recommended rate of fertilisers (Table 2). Under different cropping systems, maize-chickpea system recorded higher nutrient uptake followed by mungbean-sorghum system. *In-situ* rainwater conservation with mulching was better compared to conventional farmers' practice (Kumar *et al*., 2006; Maurya *et al*., 2020).

The significantly highest N uptake was recorded in groundnut-chickpea under recommended fertilizer application (110.1 kg N/ha). The P uptake was higher in mungbean-sorghum cropping system with mulching treatment (9.69 kg/ha) followed by maize-chickpea (M-C) cropping system with mulching treatment (8.68 kg/ha). Further, application of recommended rate of fertiliser recorded higher P uptake of 14.2 kg/ha in maize-chickpea cropping-system (Table 2). The K uptake was higher in maize-chickpea cropping system with mulching treatment (23 kg/ha). In fertilizer management system, higher K uptake was recorded in mungbean-sorghum cropping system followed by maize-chickpea cropping system with recommended practise. However, S uptake was higher in maize-chickpea cropping system with mulching and RRF (16.3 and 14.2 kg/ha, respectively). Meena *et al*. (2019) also reported higher uptake of N in maize-chickpea-greengram cropping system along with crop residue addition. The higher uptake of nutrients by different cropping systems is in accordance with the yield and its attributes. Similar results were also reported in maize-chickpea cropping system by Basavaneppa *et al*. (2017) and Prabhakar *et al.* (2022). The higher nutrients uptake recorded in maize-chickpea cropping system as compared to other cropping systems might be attributed to the higher chickpea equivalent yields (CEY) recorded in maize- chickpea cropping system with higher biomass production.

Soil nutrient status was analysed after harvest of crop. Higher available N in soil was recorded in mungbean-sorghum cropping system (285 kg/ha) as compared to other cropping systems (Table 3). Further, available P and S was higher in maize-chickpea cropping systems, however, available S was higher in mungbean-sorghum cropping system. Further, it was observed that conservation practice with recommended rate of nutrient management improved soil nutrient status in different cropping systems.

CONCLUSION

Results demonstrated that inclusion of different pulses in cropping system improved the crop yields of component or subsequent non-legume crops and thus improving the overall system productivity, economics and environmental sustainability. It was further indicated that the maize-chickpea cropping system recorded significantly higher system productivity and new returns under mulching and recommended rate of fertilizers recorded significantly higher chickpea equivalent yield and net returns compared to no mulching and farmers' management.

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