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Assessment of Browntop Millet Productivity and Fertility Status of Soil Grown as Intercropping with Different Legumes in Northern Transitional Zone of Karnataka

Darshan H. P.[1*], Chidanad P. Mansur[1], Shivamurthy D.[1] and V. M. Chaudhari[2]

[1]Dept. of Agronomy, College of Agriculture, Dharwad, Karnataka (580 005), India
[2]The Gujarat State Cooperative Agriculture & Rural Development Bank Ltd., Gandhinagar, Gujarat (382 016), India

Corresponding Author

Darshan H. P.
e-mail: darshanagri10@gmail.com

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Abstract

A field experiment was conducted during *kharif* season (June to October, 2021) at Main Agricultural Research Station, UAS, Dharwad, Karnataka, India to study the productivity and fertility status of soil as intercropping browntop millet with legumes. The experiment was laid out in randomized complete block design with thirteen treatments with three replications. Among thirteen treatments the browntop millet was intercropped with different legumes viz., groundnut, soybean, green gram and black gram in 4:2 and 2:1 row ratio and remaining treatments were individual sole crops. Among the different cropping systems, sole browntop millet was observed significantly higher grain and straw yield (973.61 and 2340.80 kg ha^{-1}, respectively), but among the intercropping systems the 4:2 row proportion of browntop millet + groundnut was recorded higher grain yield (674.31 kg ha^{-1}) and straw yield (1580.30 kg ha^{-1}). There was no significant differences were seen between the different treatments in case of harvest index, but smong the different cropping system sole browntop millet was recorded numerically higher harvest index (32.81) and among the different intercropping system browntop millet+black gram with 2:1 row ratio was recorded numerically higher value (31.00). Among the different intercropping system browntop millet+black gram at 2:1 row ratio was recorded numerically higher available N (218.16 kg ha^{-1}), P_2O_5 (28.37 kg ha^{-1}) and K_2O (271.57 kg ha^{-1}) in the soil after crop harvest.

Keywords: Browntop millet, legumes, yield, row ratio, intercropping system

1. Introduction

Browntop millet (*Brachiaria ramosa* L.) is a minor millet and is an important food crop for the poor people in the tribal areas of India, suitable for shallow gravels and poor alfislos. It is quick germinating, short duration crop tolerant to both drought and excess moisture. It becomes available for consumption at the time when there is an acute shortage of food grains in their households due to the crop is of short duration (80–90 days). Minor millets are grown in India on an area of 4,58,350 ha, producing 3,70,810 t year^{-1} with a productivity of 809 kg ha^{-1}. Minor millets are grown in Karnataka on an area of 49,000 ha, producing 37,490 t and yielding 765 kg ha^{-1} (Anonymous, 2020). Millets provide an incredible amount of nutrients. In terms of proteins, minerals (calcium and iron), vitamins, and fibre, each of the millets is three to five times more nutrient-dense than the frequently marketed rice and wheat. Calcium and iron are very much required for growing children, lactating and pregnant women who are more susceptible to anemia. When compared to all other food crops, finger millet has the highest calcium content (344 mg 100 g^{-1}), followed by foxtail millet (12.9 mg 100 g^{-1}), and little millet (10.0 mg 100 g^{-1}). Due to its high nutritional value, it not only addresses the challenge of climate change but also stands as the best way to combat malnutrition among the poor in rural areas and lifestyle diseases in urban and semi-urban areas (Reddy and Prasad, 2017). It would be advantage, if extra yield could be harvested from the same unit of land in addition to sole component. Thus intercropping of some other crops with browntop millet may be sustainable cropping system under low management conditions.

Locally, it is known as "korale" in Kannada and "anda korra" in Telugu. It thrives in the dry sections of the border regions between Karnataka and Andhra Pradesh, which include Tumkur, Chitradurga, and Chikkaballapura districts in Karnataka, and Anantapuram district in Andhra Pradesh (Sujata et al., 2018). It appears to have been a significant staple crop throughout the late prehistoric era in the larger Deccan region (Fuller et al., 2014). The information on growing of browntop millet in association with other crops is inadequate. Hence, an experiment was conducted to evaluate the comparative performance of browntop millet with different intercrops at 4:2 and 2:1 row ratio under rainfed conditions of Dharwad.

Intercropping is advantageous in many ways as it assures greater resource use, reduction of population of harmful biotic agents, higher resource conservation and soil health and more production and sustainability of the system (Maitra et al., 2020). In intercropping system, more than one crop is grown together on the same land and utilizes the soil nutrients (Xue et al., 2016; Yang et al., 2018), soil moisture (Chen et al., 2018; Singh et al., 2020), The resource conservation and soil health aspects are also advantageous in intercropping system as it checks run-off of water soil erosion and less nutrient loss from the soil. Moreover, it facilitates soil fertility enhancement (Choudhary and Choudhary, 2016) when cereals are intercropped with legumes and enables diversity of beneficial soil microorganisms (Li and Wu, 2018; Maitra and Ray, 2019). Legume intercrops are also used in cropping systems because they lower soil erosion and suppress weed growth. Cereals like maize, wheat and different millets are traditionally intercropped with legumes like green gram, cowpea, black gram, groundnut etc. Such cereal+legume intercropping system may reduce competition for nitrogen, since the legume component depends mainly on its own N fixation while the cereal uses mineral N (Banik and Sharma, 2009). Thus the study was aimed on the productivity and fertility status of soil as intercropping browntop millet with legumes.

2. Materials and Methods

A field experiment was conducted during *kharif* season (June to October, 2021) at Main Agricultural Research Station, UAS, Dharwad, Karnataka, India (located at 15° 26' N latitude, 75° 07' E longitude and an altitude of 678 m above the mean sea level). The total rainfall received during 2021 was 1052.30 mm. There were 13 treatments comprising sole and intercropping system. The experiment was laid out in randomized complete block design and replicated thrice. The land was ploughed twice with tractor drawn mould board plough in order to bring the land to the optimum tilth. The soil of experimental plot was medium deep black soil with pH 7.74, available organic carbon 0.49%, available N, P and K were 290.80, 28.30 and 331.40 kg ha^{-1}, respectively.

Sowing of browntop millet and different legumes were done on 26th July, 2021. Seeds of browntop millet (Local variety), groundnut (DH-256), soybean (DSb-21), green gram (IPM-2-14) and black gram (DU-1) were sown by using khera method (dropping of seeds through hands in furrow behind the plough) with seed rate of 7 kg ha^{-1} (Browntop millet), 100 kg ha^{-1} (Groundnut), 62 kg ha^{-1} (Soybean), 12 kg ha^{-1} (Green gram), 15 kg ha^{-1} (Black gram). Weeds were controlled through one hoeing at 30 days after sowing and one manual weeding. The recommended dose of fertilizer for browntop millet (30:15:15 kg ha^{-1}), groundnut (18:46:25 kg ha^{-1}), soybean (40:80:25 kg ha^{-1}), green gram (25:50:0 kg ha^{-1}) and black gram (25:50:0 kg ha^{-1}) in the form DAP, urea and MOP was applied at the time of sowing. In case of intercropping treatments fertilizers were applied based on the population level. The seed treatment with *Rhizobium strains* (50 g kg^{-1} seeds) for seeds of groundnut, soybean, green gram and black gram, browntop millet was treated with *Azospirullum* (50 g kg^{-1} seeds). Five plants were tagged randomly from each plot for recording various yield attributes at harvest stage. Standard procedures were used to measure the yield of both main and intercrops. Significance and non-significance difference between treatments was derived through Duncan's Multiple Range Test (DMRT) using Online Statistical Analysis Tools (OPSTAT). Nitrogen was determined by modified alkaline permanganate method (Sharawat and Burford, 1982). Phosphorus was determined Olsen's method followed spectrophotometric method (Jackson, 1973). Potassium was measured by Flame photometric method (Jackson, 1973).

3. Results and Discussion

3.1. Effect of intercropping system on yield

The results (Table 1) indicated significant influence of different treatments on grain yield of browntop millet, the

Table 1: Grain yield, straw yield and harvest index of browntop millet as influenced by intercropping with legumes

Tr. No.	Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI (%)
T_1	Browntop millet+ Groundnut (4:2)	674.31^b	1580.30^b	30.01^a
T_2	Browntop millet+ Soybean (4:2)	642.82^b	1505.30^b	29.91^a
T_3	Browntop millet+ Green gram (4:2)	642.36^b	1496.93^b	30.13^a
T_4	Browntop millet+ Black gram (4:2)	640.74^b	1465.30^b	30.39^a
T_5	Browntop millet+ Groundnut (2:1)	665.51^b	1515.22^b	30.56^a
T_6	Browntop millet+ Soybean (2:1)	642.36^b	1449.30^b	30.82^a
T_7	Browntop millet+ Green gram (2:1)	637.64^b	1449.80^b	30.80^a
T_8	Browntop millet+ Black gram (2:1)	637.04^b	1421.88^b	31.00^a
T_{13}	Sole browntop millet	973.61^a	2340.80^a	32.81^a
SEm±		27.72	64.05	1.26

Means followed by the same letter(s) within the column did not differ significantly by DMRT (p=0.05) sole browntop millet was recorded significantly higher grain yield (973.61 kg ha^{-1}). The per cent yield increased with sole browntop millet was to the tune of 30, 33, 33 and 34, respectively over 4:2 row ratio of browntop millet+groundnut, browntop millet+soybean, browntop millet+green gram, browntop millet+black gram. Whereas, 2:1 row ratio did not show much differences in grain yield (Table 1). This was mainly due to high biomass production, rapid leaf area expansion and high-tillering capacity of browntop millet (Ausiku et al., 2020).

Among different intercropping systems, 4:2 row ratio of browntop millet+groundnut was recorded numerically higher grain yield (674.31 kg ha^{-1}) and the per cent yield increased was 4.6, 4.7 and 4.9% higher compared to 4:2 row ratio of browntop millet+soybean, browntop millet+green gram and browntop millet+black gram, respectively and 1.3, 4.7, 5.4 and 5.5% higher compared to 2:1 row ratio of browntop millet+groundnut, browntop millet+soybean, browntop millet+green gram and browntop millet+black gram, respectively (Table 1). The sole browntop millet produced higher grain yield, over intercropping treatments, which can be attributed to 100% plant population and absence of competition from intercrops. Apart from above, the yield increase was due to higher grain weight per panicle, grain weight $meter^{-1}$ row length and number of panicles $meter^{-1}$ row length of sole browntop millet. Similar results have been reported by Sahu and Patro (1993), who found that when little millet was intercropped with green gram in a 4:1 row ratio and black gram in a 4:1 row ratio, as opposed to little millet grown as a sole crop, a higher grain yield was obtained in sole little millet (654 kg ha^{-1}). According to Mitra et al. (2000), finger millet grown as a single crop produced higher grain yield than finger millet grown in an intercropping system with green gram and soybean.

Among the different treatments, sole browntop millet produced significantly higher straw yield (2340.80 kg ha^{-1}) than the other treatments, the per cent straw yield increase with sole browntop millet was to the extent of 32, 35, 36 and 37% when compared to 4:2 row ratio of browntop millet+groundnut, browntop millet+soybean, browntop millet+green gram and browntop millet+black gram respectively and 35, 38, 38 and 39 % when compared to 2:1 row ratio of browntop millet+groundnut, browntop millet+soybean, browntop millet+green gram and browntop millet+black gram, respectively. Among different intercropping systems browntop millet+groundnut in 4:2 row proportion was recorded higher straw yield (1580.30 kg ha^{-1}) and the per cent straw yield was increased to the extent of 4.7, 5.3 and 7.2% as compared to 4:2 row ratio of browntop millet+soybean, browntop millet+green gram, browntop millet+black gram, respectively (Table 1). Higher dry matter production and population could be the causes of this increase in straw yield. Similar results were noted by Shivakumar and Yadahalli (1995), who found that finger millet grown as a single crop produced more straw yield than finger millet intercropped with 4:2 row ratios of fieldbean with finger millet, little millet, and foxtail millet recorded higher straw yield (14.0, 2.4 and 10.7% respectively) over 2:1 row ratio due to more space being available (120 cm vs. 60 cm between two sets in 2:1 row ratio), which results in better light availability, better resource utilization and less inter and intra-species competition. According to Prasannakumar et al. (2009), 6:2 row ratio of pigeonpea+little millet produced more straw yield than an intercropping system with 3:1 ratio. There was no significant differences were observed in case of harvest index (Table 2). However, sole browntop millet was recorded numerically higher harvest index (32.81%). Diatta et al. (2020) reported that intercropped pearl millet with cowpea in two regions of Senegal and observed a 30% increase in millet yields in central-south region compared to central north region (1101 kg ha^{-1})

3.2. Effect of intercropping system on different soil parameters

The results pertaining to the available nitrogen, phosphorus and potash status of soil after crop harvest were showed in (Table 2). There is no significant differences were seen in case of available N content in soil after the crop harvest. Numerically maximum available N status of soil after crop harvest was observed in sole black gram (226.61 kg ha^{-1}) but among the different intercropping system browntop millet+black gram at 2:1 row proportion was recorded numerically higher available N status of soil after crop harvest (218.16 kg ha^{-1}). Maximum available N content in soil after crops harvest in sole black gram as well as intercropping treatments might be due to fixation of atmospheric nitrogen by rhizobium bacteria in nodules on their roots and mineralization of N from organic residues. This could also be ascribed to the residual effect of applied chemical fertilizer to respective crops based on recommendation dose. Same results were also reported by Padhi and Panigrahi (2006), Dahmardeh et al. (2010), Sheoran et al. (2010), Girijesh et al. (2015) and Kaushal et al. (2015).

The effect of various treatments on available P2O5 in soil after crop harvest was found to be significant (Table 2). Among the different treatments sole black gram and sole groundnut was recorded significantly higher available phosphorus (29.39 and 29.21 kg ha^{-1}, respectively) in soil and it was on par with all other treatments except browntop millet+groundnut at 4:2 row ratio (22.34 kg ha^{-1}) which was recorded very low available phosphorus in soil after crop harvest. Among the different intercropping treatments browntop millet+black gram at 2:1 row proportion (28.37 kg ha^{-1}) was recorded numerically higher phosphorus in soil after crop harvest. Increase in available P_2O_5 status in soil due to pulse crops secrete greater amount of acid phosphatases in soil from roots than browntop millet. To increase plant stand of pulses in intercropping, amount of phosphorus was increased. Dahmardeh et al. (2010) and Girijesh et al. (2015) also found maximum available P_2O_5 status in soil after crop harvest in sole intercrops (legumes) followed by intercropping treatments compared to sole maize.

Table 2: Available soil nutrient status after harvest of crop as influenced by browntop millet intercropping with legumes

Tr. No.	Treatments	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	Browntop millet+ groundnut (4:2)	202.54^a	22.34^b	263.00^a
T_2	Browntop millet+ Soybean (4:2)	208.39^a	24.73^{ab}	265.00^a
T_3	Browntop millet+green gram (4:2)	215.25^a	26.12^{ab}	268.08^a
T_4	Browntop millet+black gram (4:2)	217.04^a	26.11^{ab}	268.48^a
T_5	Browntop millet+ groundnut (2:1)	205.98^a	23.17^{ab}	264.00^a
T_6	Browntop millet+ soybean (2:1)	209.42^a	25.25^{ab}	266.00^a
T_7	Browntop millet+green gram (2:1)	217.41^a	28.10^{ab}	270.26^a
T_8	Browntop millet+black gram (2:1)	218.16^a	28.37^{ab}	271.57^a
T_9	Sole groundnut	220.88^a	29.21^a	274.89^a
T_{10}	Sole soybean	220.33^a	28.59^{ab}	276.63^a
T_{11}	Sole green gram	224.36^a	28.89^{ab}	279.16^a
T_{12}	Sole black gram	226.61^a	29.39^a	282.44^a
T_{13}	Sole browntop millet	221.26^a	25.42^{ab}	273.41^a
	SEm±	9.73	1.93	12.27

The results indicated non-significant effect of different treatments on available K_2O content in soil after crop harvest (Table 2). However, available K_2O content in soil recorded numerically higher in sole black gram (282.44 kg ha^{-1}), among the different intercropping systems browntop millet+black gram at 2:1 (271.57 kg ha^{-1}) was recorded numerically higher available potash content in soil after crop harvest and browntop millet + groundnut at 4:2 row proportion (263.00 kg ha^{-1}) was recorded numerically least available potash content in soil after crop harvest. Higher available K_2O content in soil under sole legumes might be due to deep root system of legumes, they could absorb K_2O from the deep soil level and increased biological and chemical activity in rhizosphere might have resulted in higher available potassium content in soil. Similar results were also reported by Dahmardeh et al. (2010) and Girijesh et al. (2015).

4. Conclusion

Among the intercropping systems, browntop millet+groundnut in a 4:2 row ratio produced the highest grain (674.31 kg ha^{-1}) and straw (1580.30 kg ha^{-1}) yields. While no significant differences were found in soil parameters, browntop millet+black gram (2:1 row ratio) showed higher values for N and K. Sole black gram and groundnut had higher available phosphorus (29.39 and 29.21 kg ha^{-1}). The 2:1 row ratio of millet+black gram had the highest soil nutrients, enhancing soil fertility and productivity.

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