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Millet and Pulses Based Intercropping: A Review

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ABSTRACT

World's population is growing exponentially and agriculture has to fulfil their food requirements. An important strategy for increasing productivity and labour utilization per unit area of available land is to intensify land use. Intercropping is advanced agro technique of cultivating two or more crops in the same space at the same time. It increases in productivity per unit of land *via* better utilisation of resources, minimises the risks, reduces weed competition and stabilizes the yield. Millets are ancient nutri-cereals which play an important role in food and nutritional security of the country. They are commonly grown as sole crop world-wide. Pulse production can be increased by growing pulses on favourable lands that are occupied by cereals and cash crops by way of intercropping. The combination of cereal and legume in intercropping is mostly preferred by the farmers in subsistence farming targeting livelihood security. In this study, the works carried out by various researches in millet and pulse based intercropping are discussed. This review would be useful to the researchers who are involved in this field.

Key words: Economics, Intercropping, Millets, Pulses, Yield.

Prosperity of a nation depends on advancement of agriculture. In developing countries like India production of food grains should keep pace with an ever-increasing population. The day is not far when man may face the biggest famine unless, the production of food grains is increased. Due to limited area under cultivation, it is very important to increase the production per unit area per unit time and that can be done only by utilization of available resources.

In conventional farming and monocropping systems, although high yield per unit area is been able to provide the nutritional needs of growing populations in some areas, but these systems requires direct and indirect to abundant costs and energy that arise from fossil fuels. In terms of ecology and environment, monocropping has been caused a series of serious problems. Human by excessive use of resources such as water, soil, forests, pastures and natural resources not only put them at risk of extinction, but also with the creation of pollution caused by industrial activities, chemical fertilizers and pesticides, threatens the earth (Reganold, 1992). One of the key strategies in sustainable agriculture is restoration diversity to agricultural ecosystems and its effective management. Intercropping is a ways to increase diversity in an agricultural ecosystem. Intercropping as an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality and reduce yield damage to pests, diseases and weeds (Udhaya Nandhini and Somasundaram, 2020).

Growing of only cereals or cereals as sole crop is not so much remunerative in present scenario of agriculture so to fulfil the diverse demand of consumers and rapid growing population there is an urgent demand for incorporation of the pulses in cereals production system. Intercropping of millets with different pulses has greater scope to utilize the land and other resources to maximum extent. The productivity of the system can be enhanced by judiciously selecting the intercrops which differ in duration and growth in many situations (Sadashiv and Nemgouda, 2004).

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Intercropping

Intercropping plays a vital role in subsistence food production in both advanced and emerging countries (Adeoye *et al*., 2005). According to Manjunath *et al*. (2018) intercropping is a beneficial system of crop production aimed at maximizing production and profits over space and time.

Intercropping is a system that focuses on the better exploitation of sunlight, effective utilization of nutrients and water, risk reduction and higher exploration of the growth factors from the environment (Mobasser *et al.,* 2014; Ajibola and Kolawole, 2019).

In intercropping land was effectively utilized and yield was improved (Mashingaidze, 2004). Other advantages of intercropping include potential for increased profitability and low fixed costs for land as a result of a second crop in the same field (Thobatsi, 2009).

Though the millet crops have heritage and pride in India, more focus is given on rice, wheat and maize crops and its production during post green revolution period and millets

have been neglected (Thakur and Sharma, 2018). But, during recent period, millets have regained their importance because these of their nutritional benefits and ecological hardiness (Padulosi, 2011; Maitra *et al*., 2020).

Nowadays demand for food is continuously increasing worldwide due to increasing human population. Under this situation, where the yield of major cereals are fluctuating, small millets recorded a steady increase in output over last five decades as in 1955-56 yield was 388 kg ha^{-1} and in 2013-14 it was 633 kg ha^{-1} (Anbukkani *et al*., 2017). Agriculture in India faces many constraints, but millets are ecologically sound crops which can withstand in different weather aberrations with greater storability (Passi and Jain, 2014).

Advantages of millet-legume intercropping

Intercropping cereals with legume is a very common combination and it provides more advantages in terms of efficient use of available resources, soil fertility improvement, less use of chemical fertilizers (Chalk *et al*., 2014; Chavan *et al*., 2017; Jensen *et al*., 2020), controlling erosion and run-off of water and enhancing diversity (Maitra *et al*., 2019) and ultimately total productivity of crops (Jan *et al*., 2016).

Seran and Brintha (2010) attributed that, cereal + legume intercropping system being popularized as an insurance against crop failure for monocropping under rainfed conditions, the chief goal of intercropping is to ensure improved and sustainable production.

The intercropping system of cereals + pigeonpea/ legumes were tested and found to be profitable systems (Francis, 1985; Ahlawat *et al*., 2005), legume-cereal intercropping increase the fixation of nitrogen by legumes (Hardarson and Atkins, 2003). Vesterager *et al.* (2008) found maize and cowpea intercropping is beneficial on nitrogen poor soils. The initial slow growth rate and deep root system of pigeonpea offers a good scope for intercropping with fast growing early maturing and shallow rooted finger millet (Ramamoorthy *et al*., 2004). Banik and Sharma (2009) reported that cereal-legume intercropping systems were superior to monocropping. Maize-cowpea intercropping increases the amount of nitrogen, phosphorus and potassium contents compared to mono crop of maize (Dahmardeh *et al.,* 2010).

Girase *et al*. (2007) stated that the basis of pearl millet equivalent yield, net monetary returns and LER showed that pearl millet + moth bean (2:1) or pearl millet + cowpea (2:1) appears the most productive, efficient and profitable for rainfed conditions of scarcity zone of north Maharashtra. Sharmili and Parasuraman (2018) in their study stated that growing of little millet and pigeonpea in 6:1 row ratio with horsegram or mothbean in sequence have been found superior than growing sole crop of little millet alone. Also the study conducted by Padhi *et al.* (2010) revealed that raising 4:2 ratio of finger millet (*Bhairabi*) + pigeonpea (UPAS 120) under rainfed condition during the rainy season proved most productive, economically viable and energetically efficient than their sole plantings.

Performance of millets under intercropping situation

Growth and yield of a crop is the function of interaction between environment and genetic potential of the crop cultivar. When two or more crops are grown in association, the genetic potential being constant, environment component is modified, affecting the different components of growth and yield.

In terms of effect of pulses intercropping on yield attributes of little millet, Sharmili and Manoharan (2018) revealed that number of panicles $tiller^{-1}$ and 1000 grain weight of little millet is found to be increased when intercropped with pulses.

Little millet and pigeonpea in 5:1 row ratio recorded significantly higher little millet grain yield (Patil *et al*., 2010). Similar results were also reported by Shashidhar *et al.* (2000) in little millet + pigeonpea (4:2). Further he also reported from his studies in finger millet reported higher finger millet equivalent yield in 4:2 row ratio in finger millet + pigeonpea intercropping system compared to 3:1 and 5:1 row proportions. Basavarajappa *et al.* (2003) also revealed that under shallow alfisols higher foxtail millet equivalent yield (5270 kg ha^{-1}) was recorded in foxtail millet and pigeon pea intercropping system.

Yirzagla (2013) revealed that millet grain yield was significantly higher than the mean yield of 1.74t ha^{-1} when cropped under 1:1 and 2:1 ratio of millet and cowpea. Maitra *et al.* (2001) reported that finger millet produced more yield under intercropping with pigeon pea compared to grown as sole cropping. Intercropping of finger millet with blackgram or mothbean in 8:2 or 4:1 row proportion resulted in maximum grain and straw yield as well as net profit (Nigade *et al*., 2012).

Performance of pulses as companian crops

The success of intercropping greatly depends on choice of component crops of a mixture, taking into account the crop environment of a locality and the varietal availability. The perfect crop combinations and their complementary and synergistic effect if reflected in intercropping, yield benefits of both crops can be noticed.

Sharma *et al.* (2004) reported that intercropping of pigeonpea genotype ICPL-87119 (*Asha*) with greengram (15.11 q ha^{-1}) and pearl millet (13.87 q ha^{-1}) recorded significantly higher seed yield as compared to ICP-8863 (*Maruti*) genotype intercropped with greengram (13.69 q ha^{-1}) and pearl millet (12.56 q ha^{-1}). The seed yield of greengram and pearl millet were more when intercropped with *Asha* (3.24 and 5.46 q ha^{-1}, respectively) genotype as compared to ICP-8863 (*Maruti*) (2.96 and 5.04 q ha^{-1}, respectively). Also, Narendra *et al.* (2010) reported improvement in plant height, pods $plant^{-1}$, grains $plant^{-1}$, grain weight $plant^{-1}$ and horsegram equivalent yield (HEY) were recorded in intercropping over sole horsegram when intercropped with finger millet, Light penetration was also improved under intercropping (1.3 per cent in sole horsegram, net return

(Rs.7526 ha^{-1}) and benefit: cost ratio (1.34) were highest under horsegram + finger millet followed by horsegram + maize.

When maize is intercropped with blackgram, greengram, cowpea, higher grain yield was achieved from the maize crop with cowpea (3.97 t ha^{-1}) followed by maize intercropping with millet (2.98 t ha^{-1}), greengram (3.83 t ha^{-1}) and blackgram (3.96 t ha^{-1}). Intercropping of legumes proved to be beneficial over non-legume as it assisted for higher maize yield (Dhakal *et al.*, 2014). But in controversy, some researchers have also reported negative response on associated crops. Patil *et al.* (2010) reported higher grain yield of pigeonpea (682 and 637 kg ha^{-1}) was recorded in sole pigeonpea. Shashidhar *et al.* (2000) also reported similar results in little millet + pigeonpea intercropping.

Biological feasibility

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.,* 2019).

Himasree *et al*. (2017) reported that the land equivalent ratio (LER), Area Time Equivalent Ratio (ATER) and foxtail millet grain equivalent yield were more with the intercropping system of foxtail millet + pigeonpea (5:1). In another study, Manjunath and Salakinkop (2017) showed that intercropping of soybean + foxtail millet at row proportion of 2:1 and 4:2 recorded advantageous LER values (1.49 and 1.50 respectively). Maitra *et al.* (2000) studied finger millet-legume intercropping system in replacement series and noted greater value of ATER with the combination of finger millet and red gram (4:1).

Pulses and soil fertility

Legumes enrich soil by fixing the atmospheric nitrogen converting it from an inorganic form to forms that are available for plants uptake. Biological fixation of atmospheric nitrogen can replace nitrogen fertilization wholly or in part. Biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems when nitrogen fertilizer is limited (Fujita *et al*., 1992).

Ansari *et al.* (2011) reported that based on two years mean pearl millet equivalent yield of intercropped stand was 46.1 and 10.2 per cent higher than sole stand of pearl millet and pigeonpea. On an average intercropped stand recorded 27.2 kg grain kg^{-1} N and Water Use Efficiency of 10.55 kg ha^{-1} mm, which was 86.5 and 17.8 per cent higher than pearl millet and 287 and 126.6 per cent higher than pigeonpea respectively. Also, Tripathi and Kushwaha (2013) reported that nutrient uptake of pearl millet in terms of N, P and K was significantly increased under intercropping system, protein content did not affect significantly due to intercropping system.

Furthermore, Kalu Ram and Meena (2014) also revealed that the intercropping of pearl millet with mungbean in 1:7 ratio recorded higher pearl millet equivalent yield (4036 kg ha^{-1}), LER (28%), net returns (Rs. 36380 ha^{-1}) and better nutrient uptake compared to sole and other intercropping treatments.

Monetary return

Economics or monetary return of particular intercropping system is supposed to be the most important aspect from the crop production point of view. Intercropping mainly aims at maximum production and net return per unit of time and space. Even though the yield of main crop was found to be reduced due to inclusion of intercrops in intercropping systems, higher monetary return was recorded by many research workers in India, which is attributed to the bonus obtained from component crop. According to Seran and Brintha (2010) the intercropping system gave higher cash return to smallholder farmers than growing as the monocrops.

Intercropping of pearl millet with greengram recorded highest net return and B:C ratio over sole pearl millet (Hooda *et al*., 2004; Kuri *et al*., 2012). Similarly, Sharmili *et al.* (2019) observed higher gross return (Rs. 86,379 ha^{-1}), net return (Rs. 48,209 ha^{-1}) and benefit cost ratio (2.26) were little millet is intercropped with pigeonpea at 6:1 ratio with horsegram as sequence crop. Also, Dubey and Upadhyaya (2001) reported that when short duration littlemillet (JK-8) is intercropped with medium duration pigeonpea (No.148) in 2:1 planting ratio, it gave higher little millet GEY (1903 kg ha^{-1}), with highest Net monetary return (Rs.4335 ha^{-1}) and B:C ratio (1.91).

Studies on enhancing productivity of field bean in finger millet based cropping systems at Coimbatore showed that intercropping determinate type of field bean with finger millet variety Co 11 in 8:1 row proportion was a remunerative choice (Rs. 13360 NMR ha^{-1}), (Gowda *et al.,* 2004).

Ramamoorthy *et al.* (2004) reported higher net return from pigeonpea and finger millet intercropping system obtained at 2:4 row ratio. Anchal Dass and Sudhishri (2010) also reported that higher LER (1.34), net returns (Rs. 9665 ha^{-1}) and B:C ratio (1.00) when finger millet is intercropped with pigeonpea in 6:2 ratio.

Choudhary *et al.* (2012) stated that intercropping of pearl millet with green gram at 2:2 row ratio was distinctly superior over sole pearl millet and found most profitable by realizing the highest net return and LER. Pradhan *et al.* (2014) reported that the economics of intercropping on finger millet with pigeon pea combination was found to be the best in obtaining highest net returns of Rs. 36444 and Rs. 21384 ha^{-1} in respective years (2005 and 2006) and also highest (20.57 and 17.64 q ha^{-1}) yield was recorded in finger millet + pigeon pea intercropping, followed by horse gram and black gram and minimum was in finger millet + niger intercropping.

CONCLUSION

It is very certain that India lacks a balance between natural resources and agricultural food productivity. Resources for agriculture such as suitable land, nutrients and most importantly irrigation water, remain very scarce. Proper utilization of the available natural resources can be achieved

only by better and suitable intercropping practices. Potentiality of intercropping is well known for multifaceted benefits like greater resource use, reduction in the population of harmful organisms, higher resource conservation efficiency and ultimately soil health and agricultural sustainability. On the other hand, small millets are the important and ecologically hardy crops of drylands which can provide us food and nutritional security. On the basis of available literature studied it can be concluded that intercropping small millets with pulses is one of the best suitable options to harness ecologically sound agriculture.

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