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PRODUCTION POTENTIAL OF MULTICUT SORGHUM AND PEARL MILLET HYBRIDS UNDER INTERCROPPING SYSTEMS - A REVIEW

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SUMMARY

In India and in the hilly regions, crop residues, cultivated forages, pastures and grasslands are the main sources of livestock feed, but inadequate availability of qualitative feed and fodder adversely affects livestock productivity. Although, shortage of animal feed and fodder is a major issue that needs to be addressed but simultaneously quality of feed and forage cannot to be ignored. Green forage availability is very important to maintain livestock health and productivity and this is particularly essential in dairy entrepreneurship where consistent and regular supply of green fodder is imperative to sustain the milk production. Green herbage in addition to energy also provides vitamins, minerals with better dry matter digestibility. Good quality forage helps to meet out 90 per cent of energy and protein requirement of ruminants. In the country, farmer faces rapid inflation in the cost of animal feed. Feed accounts for 70 per cent of the cost of production and this can be brought down to 30-40 per cent, if sufficient quantity of quality forage is available. Sorghum and pearl millet are two of the tropical region's gifted genera that provide food, feed, stove, and fuel for millions of poor farming families and their livestock. This paper reviews the literature on intercropping of sorghum and pearl millet hybrids along with other essential cereal legume mixture.

Key words : Feed, forage, intercropping, mixture, production

Livestock plays an important role in rural economy of India by providing employment and supplementing family income by contributing about 21 per cent of the total agriculture income of the family (Sharma *et al*., 2009b). The livestock sector accounts for almost 32 per cent of the agricultural sector contributing 22 per cent of Indian GDP as a whole (Swathi *et al*., 2020). In country, the fodder requirement of livestock is mostly met through low-quality crop residues and degraded grasslands, which are not sufficient for the maintenance of animal health and productivity. Due to an increase in population at a rapid rate of around 3% per year, it is impossible to increase the area for the production of feed. Thus, the only way to meet the feed requirement for livestock is to increase the amount per hectare (Iqbal *et al.,* 2013). Among cultivated fodder crops sorghum (*Sorghum bicolor* L.) is an important *kharif* season crop which gives good biomass in first cut in most of the cultivars, but the regeneration capacity of this crop is not so good. However, pearl millet [*Pennisetum glaucum* (L.) is one of the important millets crop of hot and dry areas of arid and semi-arid climatic condition (Yadav *et al*., 2018). It has good regeneration capacity after first cut and gives good tonnage in subsequent cuts compared to sorghum. This is the best meal for animals during the summer season and is usually grown in rain-fed areas of Punjab. It's excellent in providing a lot of dry matter; that's why farmers as well as animals also like it best (Islam *et al.*, 2018).

To have more forage yield and better seasonal distribution of the green fodder, the farmers have started to grow newly released sorghum and pearl millet hybrids in combination, due to their differential growth and regeneration behaviour. Intercropping of sorghum and pearl millet with different growth cycles is used widely in third world countries to ensure and increase yields.

Mixed cropping, a predominant feature in the cropping systems, is a means of maximizing the use of limited farmlands and also for food security to the subsistence farmers (Bhupinder *et al*., 2003). In a

mixed cropping system, the plant arrangement and their densities alter the amount of light transmission to the lower layers of the crops and affect the competition of species for light, water and nutrients (Khalatbari *et al*., 2009). The type of mixed crop and spatial arrangement in mixed cropping has important effect on the balance of competition between the component crops and their productivity. To get the best results, a rational approach is required for obtaining an appropriate plant population of inter/mixed crop stand. The concept of growing more than one crop in combination is to get increased total productivity per unit area and time besides equitable and judicious utilization of land resources and farming inputs (Marer *et al*., 2007). The type of inter/mixed crop and the spatial arrangement of inter/mixed crop have significant effects on the balance of competition between the components of the crop and their productivity. In order to achieve the best results, a rational approach is needed to obtain information on the appropriate inter/mixed crop population (Guleria *et al*., 2018).

The relationship between the two crops under intercropping is somewhat complex because the maximum yield to be obtained will depend upon many factors including species, cropping systems and environmental conditions. Intercropping plays a significant role in agriculture through effective utilization of resources and improving crop productivity (Reza *et al*., 2013). Yield production through intercropping is higher than single-cropping because light, water and nutrients are more efficient in intercropping than single-cropping (Ali *et al*., 2016). However, the information on the compounding of multicut sorghum with pearl millet hybrids particularly with respect to different intercropping systems is lacking.

In view of all this, a thorough analysis of the effects of intercropping of sorghum and pearl millet under the following headings on various aspects has been discussed:

Effect on plant growth and development

Several scientific studies have demonstrated that crop growth in terms of plant height, number of leaves per plant and dry matter accumulation per plant at various stages of crop growth varies under various multiple cropping systems compared to mono-cropping. Multiple cropping either exhibit a positive, negative or no effect on growth and development of each component crop.

Positive effect

Intercropping of legumes with cereals has been shown to increase growth and development of main cereal crops. The study of Singh and Balyan (2000) at Indian Agricultural Research Institute, Delhi indicated better plant height, leaf area index (LAI) and per plant dry matter accumulation of sorghum when grown in association with cluster bean.

Kumar and Bhanumurthy (2001) at ANGRAU, Hyderabad reported significant improvement in fresh and dry weight of pearl millet, maize and sorghum when sown with cowpea. The study further indicated better growth performance of pearl millet with cowpea than maize and sorghum. The study further indicated better growth performance of pearl millet with cowpea than maize and sorghum. Under rainfed conditions at Hisar, Ram and Singh (2001) also found better growth of sorghum when grown with cowpea and cluster bean. The study further established cowpea as better intercrop than cluster bean with sorghum.

The study of Sharma *et al*. (2009a) at Sabour, Bihar also found beneficial effect of legumes intercropping on plant height of pearl millet. Reza *et al*. (2013) at Tehran (Iran) observed higher fresh and dry weight of sorghum when grown with lima bean (*Phaseolus lunatus*) in additive series at different planting proportions of crops. Refay *et al*. (2013) in Saudi Arabia reported that sorghum plants when intercropped with cowpea had more plant height, number of leaves per plant, stem diameter and leaf area. Guleria (2013) at Palampur (H.P.) observed that broadcast sowing of sorghum with 75 per cent of recommended seed rate of cowpea resulted in better plant height, plant population and dry matter accumulation of sorghum. Ibrahim *et al*. (2014) in Pakistan also indicated a significant improvement in plant height of maize with increasing seed ratio of cluster bean and cowpea as intercrops.

Akhtar *et al*. (2013) in Faisalabad (Pakistan) observed that sorghum sown alone in 30 cm apart rows produced maximum plant population, plant height rather than being intercropped with cluster bean. The findings of Oskoi (2015) at New Delhi suggested that the sole cultivation of maize and fababean surpassed the intercropping of these crops in the sense of growth parameters such as plant height, number of pods / plant etc.

Negative effect

Certain studies have indicated mutual

inhibition effect of crops while grown in combination with each other. The findings of Kumar *et al*. (2008) at Dharwad (Karnataka) reported adverse effect on the growth of sorghum with the involvement of legumes as intercrop. The study of Ayub and Shoaib (2009) in Faisalabad (Pakistan) also indicated a significant reduction in plant height of sorghum when sown with cluster bean using different seeding techniques. The study of Forsatian *et al*. (2010) at Tehran conclusively indicated an adverse effect on growth of sorghum with the inclusion of cowpea and soybean as intercrop.

Akhtar *et al*. (2013) in Faisalabad (Pakistan) observed that sorghum sown alone in 30 cm apart rows produced maximum plant population, plant height rather than being intercropped with cluster bean. The findings of Oskoi (2015) at New Delhi indicated that sole cropping of maize and fababean was superior to intercropping of these crops in context of growth parameters like plant height, number of pods/plant etc.

The literature indicated that multiple cropping have variable effects on the growth of crops, however, the extent of effect varied from region to region and also with type of crops grown in association with each other.

Yield and productivity

Crop diversification also provides many agronomic and ecological benefits while sustaining and improving the size and quality of production. Inter/ mixed cropping is one of the many forms of crop diversification. A little work being done on cereal-cereal mixtures as well as investigations have been carried out in past few years to see the effect of cereal-cereal and cereal-legume mixture on quantity and quality of produce.

Positive effect

Several studies have indicated that in intercropping system, yield suppression of any of the component crops is generally offset by yield increase of the other crop. But in totality many findings of different scientists have found superiority of intercropping over sole cropping in terms of total productivity of the system.

The findings of Osman and Nersovan (1986) in Northern Syria established the superiority of cereal: legume intercropping (66:33 seed ratio) over sole stand of each crop. Chittapur *et al*. (1992) also reported complimentary effects of 1:1 intercropping of fodder bajra with grain maize. Sunitha and Sreekanthan (1994) at Vellayani (Tamil Nadu) observed yield benefit in maize + cowpea intercropping systems. Cowpea as an intercrop in maize generated higher yields of green and dry fodder than sole crops (Babu *et al*., 1994). Arunachalam *et al*. (1995) at Coimbatore studied the various intercropping systems of bengal gram, sorghum, cumbu (*Pennisetum glaucum*), sesame, mustard (*Brassica juncea*) and soybean and established yield advantages with intercropping over sole cropping as was evident from higher values of land equivalent ratio of 1.26 to 1.56. Caballero *et al*., (1995) at Madrid (Spain) while studying the effect of oat + vetch (*Vicia sativa*) compounding on forage yield at varying seed ratios found an increase in relative yield total of mixtures comprised of higher seed proportion of vetch. Hussain *et al*., (1999) in South Africa also found positive effects on forage productivity by compounding of sorghum with cluster bean (*Cyamopsis tetragonoloba* L.) in 2:3 intercropping systems. Under arid conditions of Jhansi, Arya *et al*. (2000) reported sorghum + pigeon/cowpea systems highly productive and sustainable systems. In Maharashtra, Desale *et al*. (2000) reported sorghum + cowpea as most productive, stable and profitable system under rainfed conditions. In an intercropping system, optimum plant population *vis-à-vis* optimum space for growth of individual plant determines the productivity of the system. The research work of Wondeamlak *et al*., (2001) in Netherland examined barley and wheat mixtures and revealed a yield advantage as a result of complementary use of resources by barley and wheat mixtures. Barley displayed greater competitiveness than wheat; interspecific competition for wheat was greater than intra-specific competition, whereas intra-specific competition for barley was greater than interspecific competition. Sardana and Narwal (2005) at Hisar (Haryana) established higher productivity of berseem + brassica crops based mixed cropping systems. Kumar and Ramawat (2006) at Palampur (Himachal Pradesh) observed higher mean guinea grass equivalent yield (613.68 q/ha) and LER (1.33) when guinea grass was sown with maize in 1:1 seed proportion. The research reports of Tulasa (2006) at Ladakh (Jammu and Kashmir) reported lucerne a better companion crop with mustard, buckwheat, foxtail millet and chickpea.

In Faisalabad, Pakistan, Ahmad *et al*., (2007) reported higher forage yield (46.1 t/ha) of sole sorghum grown in 45 cm spaced paired rows. Although legume association decreased the forage sorghum yield but

based on total yield, intercropping of sorghum with legumes was more productive and profitable than monocropped sorghum. Research work by Patel *et al*. (2009) at Anand (Gujarat) established the superiority of lucerne + chicory (*Chicorium intybus* L.) cropping in terms of forage and dry matter yields over the sole cropping. Another experimental study of Jakhar *et al*., (2009) at Sardarkrushinagar (Gujarat) also established the superiority of lucerne + chicory intercropping systems. Khalatbari *et al*. (2009) under arid climatic conditions of Tehran, evaluated the efficiency of intercropping of sorghum with pearl millet and found higher forage yield when these crops were grown using 75 per cent seed of sorghum and 25 per cent seed of pearl millet. Beidokhti *et al*. (2010) while studying the effect of variable seed rates of cowpea with sorghum, observed the increase in herbage yield of mixtures over pure stand. Sorghum fodder yield decreased proportionally with increasing seed rate of cowpea but this yield reduction of sorghum in the intercropping system was compensated by the yield of cowpea under respective treatments. A field experiment by Ganvit *et al.,* (2018) was conducted in Gujarat to study the performance of forage based intercropping of oat (*Medicago sativa* L.) – lucerne under different row ratio which indicated that oat + lucerne in the ratio of 2:1 recorded significantly higher green fodder yield (991.14 q/ha) of oat and lucerne along with significantly higher dry fodder yield (114.12 q/ha) of oat. Deori *et al.,* (2019) while studying the performance of three perennial grasses under sole and intercropping systems under two different planting methods revealed that the alternate row and column method incurred significantly higher green forage yield whereas hybrid napier as sole cropping and intercropping of setaria + guinea recorded the highest dry mater and crude protein yield.

The literature above reviewed clearly indicated beneficial effect of combined cropping under different growing situations, however, few studies had shown non-significant effect of intercropping on productivity of the systems.

Negative effect

Few studies have reported inhibitory effects of mixed cropping on associated crops. Baker (1979) in Nigeria observed that the grain yield of mixtures was rarely reduced when millet, maize and sorghum were grown in alternate row mixtures. In Tamil Nadu, Ramamoorthy *et al*. (1988) reported a decrease in overall productivity when millet was planted in 3:1 or 4:1 row patterns. Jonusiena *et al*. (1991) reported reduction in fodder yield of maize when maize was grown with *Brassica campestris* × *Brassica chinensis*, a non legume crop.

In an experiment in Karnataka, Amedie *et al*., (2004) reported significant reduction in sorghum yield with the intercropping of legumes, however, the combined yield of main and intercrop was better than sole stand. The study of Forsatian *et al*. (2010) at Tehran also conclusively indicated an adverse effect on growth and yield of sorghum with the inclusion of legume *viz.* cowpea and soybean as an intercrop. The combined yield of main and intercrops, however, was considerably better than the respective single crop stand. Renu *et al*. (2017) at Hisar conducted a experiment to study the performance of sole copping of pearl millet and green gram hybrids as well as intercropping combinations of pearl millet hybrids with green gram variety MH 421 in paired rows (30 : 60 cm) in 2 : 1 row ratio Intercropping of green gram with pearl millet hybrids in 2:1 row ratio produced statistically at par pearl millet grain yield as compared to their sole stands, however, the per cent decrease was 8.5, 3.4, 5.6 and 9.6 in the intercropping treatments of pearl millet hybrids HHB 67 Improved, HHB 197, HHB 226 and HHB 234, respectively.

The literature above demonstrate variable effects of multiple cropping on yield under different parts of the world, however, in most of the studies, positive effect of inter/mixed cropping on total productivity has been observed.

Quality

Cereal fodders are likely a source of animal energy. It is well established that balanced and complete nutrition is essential to sustain the growth of livestock to maintain optimum productivity and profitability. Supplementation of proteins and other essential nutrients in animal's diet through concentrates is an expressive preposition and result in high feed cost, which makes the livestock industry an uneconomical entrepreneur to farmers and especially to small and marginal farmers who are tied to subsistence level of living. Therefore, it becomes imperative to grow two or more forage crops in mixture with variable quality constituents.

Kumar and Bhanumurthy (2001) at Hyderabad reported increase in crude protein contents with increasing proportion of the cowpea in maize +

cowpea system, whereas, an inverse relationship was observed with respect to crude fibre content. Studies conducted by Thipeswammy and Alagundagi (2001) revealed that sweet sorghum + field bean in 2:1 row ratio was most suitable combination in terms of crude protein (812 kg/ha), crude fibre (3,820 kg/ha) yields which was followed by sorghum + cowpea grown in 2:1 row proportion. Puri *et al*. (2005) at Ludhiana studied the quality performance of ryegrass mixture with shaftal + oat and shaftal + sarson. The crop's mixture improved the quality of fodder in terms of crude protein content and in vitro dry matter digestibility. The study of Dhar *et al*. (2006) indicated that the sowing methods had no significant effect on crude protein content of sorghum and cowpea, however, broadcast sowing method resulted in higher crude protein yield owing to better dry matter yield under this method of sowing. The study of Nakagawa *et al*. (2009) in Brazil reported a significant improvement in quality of herbage by intercropping *Dolichus lablab* and *Crotolaria juncea* with sorghum. Guleria (2013) observed higher crude protein yield under broadcast sowing of sorghum + cowpea. The findings of Tahir and Zafar (2016) in Pakistan evaluated the quality performance of wheat, oat and barley sown alone and in mixture with different seed proportions and concluded that the highest crude protein (13.1 per cent) was obtained from oat + barley sown with 75+25 per cent seed ratio, whereas, minimum crude protein content of 8.7 per cent was found in sole stand of wheat. Sobkowiz *et al*. (2016) also reported increased protein yields when oat, wheat, triticale were sown in mixtures as compared to their respective sole stand. Ganvit *et al.* (2018) conducted an experiment and studied the effect of forage based intercropping of oat (*Medicago sativa* L.) – lucerne (*Avena sativa*) under different row ratio indicating that oat and lucerne in 2:1 row ratio recorded significantly higher crude protein and crude fibre content as compoared to other treatments at first and second cut.

Negative effect

Certain studies on intercropping indicated non-significant or inhibition effect on quality of forage in comparison to pure stand of crops. Tukel and Yilmaz (1987) at Adana (Turkey) reported that inclusion of cereals as intercrop with legumes significantly reduced the crude protein content in mixture compared to their sole stand whereas, Kumar *et al*. (2008) observed no significant effect on quality of produce of various crops when grown in mixture. At Tehran, Khalatbari *et al*. (2009) also reported higher percentage of digestible dry matter and carbohydrate in 75 per cent sorghum + 25 per cent pearl millet combination but the highest percentage of crude protein was observed in sole sorghum.

Economics

Multiple cropping is considered a successful preposition when overall economic in terms of net returns from system is concerned. A series of papers evaluated experimental data that indicated intercropping as better and more dependable system than sole cropping of respective crops.

Amedie *et al*. (2004) in Karnataka observed significantly higher net returns and B:C ratio in intercropping system of sorghum + french bean. Higher net returns and B:C ratio were also obtained in maize + cowpea intercropping system by Chalka and Nepalia (2005). Ahmad *et al*. (2006) obtained higher monetary returns when sorghum + cowpea were grown in planting pattern of 1:1 row arrangement in additive series. Higher B: C ratio and net gains were also reported by mixing sorghum sudan grass with cowpea over sole sorghum sudan grass and cowpea by Sharma and Chander (2006) at Jhansi. Sowing methods of crops have influenced growth and yields of crops which ultimately reflects its effect on monetary returns. The studies of Dhar *et al*. (2006) at Jhansi, U.P. reported that broadcast sowing of cowpea is more profitable than line sowing as it realized higher net returns (Rs. 16,800/ha) with better B:C ratio (1.45). Sharma (2008) in Rajasthan observed the maximum net returns (Rs. 47,300/ha) and B:C ratio (3.27) in case of pearl millet and cluster bean intercropped with a row ratio of 2:2 than sole stands of both the crops. Patel *et al*., (2009) in Gujarat, also observed significantly higher net returns and B:C ratio in lucerne + chicory (*Chicorium intybus* L.) cropping system as compared to sole cropping. In Gujarat, Jakhar *et al*. (2009) observed higher net returns and benefit cost ratio in lucerne + chicory sown in 1:2 row ratio as compared to sole stand of crops. Surve and Arvadia (2012) also reported that sorghum + cowpea (2:1) secured the maximum gross (Rs. 60,744/ha) and net (Rs. 50,031/ha) returns along with the higher B:C ratio of 5.67 followed by sorghum + cowpea (1:2) and sorghum + cowpea (1:1). Guleria (2013) observed that broadcast sowing of sorghum and cowpea crops using 75 per cent of recommended seed rate of cowpea

resulted in higher profitability. Deori *et al.* (2019) recorded significantly higher net profit and benefit-cost ratio under sole cropping of setaria and intercropping of hybrid napier with setaria in alternate row and column method.

The literature cited above revealed that the profit in terms of gross returns, net returns and B:C ratio increased with inclusion of additional crop in a system over the sole stand of crop. Consequently, crop mixtures may be considered a more remunerative enterprise than single cropping.

CONCLUSION

The above illustrated studies clearly indicate the advantage of cereal- grass intercropping along with certain beneficial grass-legume intercrops. The review here depicts the enhanced production potential of grasses like sorghum, pearl millet, maize, cowpea etc. Mixed cropping has varying and enhanced effects on growth, green as well as dry forage yield, quality and economic returns in terms of gross returns, net returns and B:C ratio. However, the range of effect varied depending upon the type of crops in association with each other, sowing methods, different seed and row proportions of crops including the regional variations.

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