The Pharma Innovation Journal 2017; 6(10): 385-390

www.ThePharmaJournal.com
The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating 2017: 5.03
TPI 2017; 6(10): 385-390

www.thepharmajournal.com
Received: 25-08-2017
Accepted: 26-09-2017

Sarita Rani
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India

Renu Goyat
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India.

Jeetendra Kumar Soni
Scientist at KVK, Katni, Piproudh Madhya Pradesh, India

Correspondence
Sarita Rani
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India

Pearl millet [*Pennisetum glaucum* L.] intercropping with pulses step towards increasing farmer's income under rainfed farming: A review

Sarita Rani, Renu Goyat and Jeetendra Kumar Soni

Abstract
Pearl millet occupies the prime position in the rainfed farming in arid and semi-arid regions of India. Its adaptation to higher temperature, scanty rainfall, poor fertile soils *etc* leads its more importance in climate change scenario. Its sole cultivation is often risky and to avoid risks in rainfed areas, generally farmers grow green gram, cowpea, moth bean, black gram and cluster bean in mixed stand as well as in intercropping. Additionally limiting land resources equipped with poor soil fertility status leads to finding way for efficient resource utilization with enhancing productivity per unit area and time, which can be obtained by intercropping and legume based intercropping witnessed higher production with additional benefits which make this more suitable intercropping choice. This review supporting the production scenario of pulses intercropped with pearl millet is presenting in paper to help farmer in making decisions regarding crop selection.

Keywords: Intercropping, yield attributes and yield, pearl millet and legumes

1. Introduction

Pearl millet [*Pennisetum glaucum* L.] occupies third position in food grain crop after wheat and barley in India. It is commonly known as Bajra, Indian millet, Bulrush millet, Cattail millet and Pencillaria. It possesses drought-escaping mechanism besides having inherent adaptation to drier and low fertile soils which leads to its prime position in dryland agriculture. Additionally, it is a rich source of minerals, vitamins, fibres *etc*. and thus contributes to securities of food, nutrition, fodder, fibre, health, livelihood and ecology (Changmei and Dorothy, 2014) [1].

Today, it is getting more attention due to increasing evidence of low and erratic precipitation, terminal heat, frequent occurrence of extreme weather events coupled with scanty water resources. It occupies a distinct position in agricultural economy of the country (Ansari *et al.*, 2012) [2]. India is the largest producer of pearlmillet in the world with 7.1 million hectare area and 9.1 million tonne per year grain production with average productivity of 12.72 q/ha during 2015-16 (Anonymous, 2016) [3]. In India, pearl millet, which accounts for more than 90% of the total area under it, is mostly cultivated in the state of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana.

Limited availability of land resources and declining soil fertility both globally and as well locally, heightened the concerns regarding agriculture's ability to sustain the demands of ever increasing population. To increase and sustain agriculture productivity we have to look for the ways of using available land and resources more effectively than in the past. This objective can be achieved by intercropping, which is an effective practice to augment the total productivity per unit area of the land per unit time by growing more than one crop in the same field, with the prime objective of better utilization of available environmental resources. Earlier, the concept of mixed and intercropping was for subsistence farming, but now a days, this concept has been changed into maximization per unit area and time.

The basic concept of intercropping system involves growing together two or more crops with the assumption that two crops can exploit the environment better than one and ultimately produce higher yield since the component crops differ in resources use and when grown together, they complement each other and make overall better use of resources (Yadav *et al.*, 2015) [4]. Intercropping is growing two or more crops simultaneously on same piece of land in distinct row arrangement with the objectives to optimize the use of natural resources, to stabilize the yield of crops and to obtain higher economic returns (Willey, 1979; Thakur *et al.*, 2000; Sobkowicz, 2006) [5-7]. Intercropping with specific planting geometry and selection of compatible crops is a profitable practice to make use of available light, soil moisture and nutrients more efficiently thus, improving productivity of dryland crops (Kaushik and Gautam, 1987) [8]. The biggest complementary effect and yield advantages occur when the component crops have different growing periods to make their major demand of resources at different time. Therefore, the crops, which mature at different time thus separating their periods of maximum demand for nutrients, moisture, space and light, could be suitably intercropped (Enyi, 1977) [9].

Research work in rainfed areas has shown that intercropping with better selection of compatible crops and proper nutrient management is a profitable practice to make use of available soil moisture and nutrients more efficiently and *per se*, improving productivity of dryland crops (Goswami *et al*., 2002) [10]. Most suited intercrops with pearl millet are green gram, black gram, pigeon pea, cowpea and cluster bean. Intercropping of either of these legumes increased the land equivalent ratio and monetary returns considerably (Bhatnagar *et al*., 1998) [11]. This review is for providing essential knowledge to farmers and research scientists regarding the benefits of pulse based intercropping in pearl millet in terms of equivalent yield, land and resources utilization, yield attributes and yield in pulses intercropped with pearl millet.

2. Benefits of legume based intercropping

Pulse based intercropping in cereals have many advantages as both differ in their growth behavior and input requirements which leads to efficient utilization of resources and increasing productivity with enhancement in soil health by taking advantage of biological nitrogen fixation by pulses. Intercropping may also increase the production per unit time without affecting the production of main crop to a great extent when leguminous crops are used as intercrop, improve soil fertility by fixing atmospheric nitrogen (Donald, 1963; Aiyer, 1967; Francis and Heicnel, 1973) [12-14]. Presence of leguminous crops in the mixture benefits the associated non-leguminous crops, as they provide a portion of biologically fixed nitrogen to non-leguminous components (Kurdali *et al*., 2003) [15]. Further, the leguminous crops increase content of nitrogen in soil and help in maintaining soil fertility (Gregorich *et al.*, 2001; Gathumbi *et al.*, 2003) [16, 17]. Intercropping also helps in improving the efficiencies of nutrients, moisture, light and better management of pest control, which ultimately leads to higher productivity (Baldev *et al*., 2005) [18].

Yield improvement by intercropping is attributed mainly to the complementary effects (Jensen, 1996) [19], better resource use efficiency of the intercrops and buffering effects of the intercrops against weeds and diseases (Willey, 1979; Anil *et al.*, 1998; Siner *et al.*, 2000; Deksen *et al.*, 2002) [20, 23]. Intercropping positively helps in the soil conservation by improving soil fertility (Jarenyama *et al.*, 2000) [24].

3. Effect of intercropping on growth parameters

Intercropped plants may decrease, increase, or maintain their normal height depending on the nature of interference of the component crops. Misra (1996) [25] recorded more plant height of both cluster bean (base crop) and pearl millet (intercrop) under triple rows of cluster bean at 30:90 cm + 3 rows pearl millet planting system. He further reported lower dry matter per plant in cluster bean under intercropping system with minimum dry matter under triple row system, whereas, dry matter of intercrop (pearl millet) did not vary under different intercropping systems. Singh and Khan (2003) [26] observed that intercropping did not affect the crop growth negatively. Yadav *et al.* (2015) [27] observed that the main crops (moth bean and cluster bean) and the intercrop (pearl millet) recorded the maximum plant height under 5:1 planting system.

The sole pearl millet recorded significantly more number of tillers per plant than the intercropping systems of pearl millet + green gram, pearl millet + cluster bean and pearl millet + cowpea (Baldev *et al.*, 2003) [28]. Baldev *et al.* (2005) [29] observed maximum plant height of sole pearl millet, however, being at par with the height under pearl millet + cluster bean intercropping system. Ansari *et al.* (2012) [30] reported an average increase of 9.62 cm in plant height and 1.9 in number of tillers per metre row length in sole stand of pearl millet than intercropping system at maturity stage. Intercropping system decreased the leaf area index by 6.5 and 11.1 per cent over sole cropping of pearl millet at 60 DAS and maturity stage, respectively. The crop growth rate of sole stand increased 12.2 per cent during 30-60 DAS over intercropping system.

4. Yield attributes and yield

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

Singh *et al.* (1981) [31] found that intercropping of green gram and cluster bean in between the rows of pearl millet had no adverse effect on its grain yield and gave additional grain yield of 100-163 and 564-895 kg/ha, respectively. Anjeneyula *et al.* (1982) [32] reported that intercropping of pearl millet triple rows 30 cm apart in an interspace of 90 cm between 2 rows of *Vigna radiata* increased the *Vigna radiata* yield by 13-16 per cent as compared with intercropping in paired rows 30 cm apart in interspaces of 70 cm and the total yield of all the intercropping systems was higher than the yield of pearl millet in pure stand.

The paired rows of pearl millet and 100 cm uniform row spacing with two rows of cluster bean gave additional yield of 4.7-6.2 q/ha under rainfed conditions and no adverse effect was observed on grain yield, stover yield and 1000 grain weight of pearl millet crop (Singh, 1985) [33]. Rana *et al.* (1986) [34] tried pearl millet in rows 45 cm apart or paired rows 30 and 60 cm apart alone or intercropped with mung bean or cluster bean and found that pearl millet grain yield was not affected by intercropping except when grown in rows 45 cm apart or intercropped with mung bean. Pearl millet in paired rows with cluster bean intercropped between wider row spacing gave the highest grain equivalent yield of pearl millet. Kaushik and Gautam (1987) [35] showed that productivity per unit area increased considerably when pearl millet was intercropped with one row of cowpea or green gram in paired rows.

The paired rows of pearl millet intercropped with 1 or 2 rows of cluster bean produced grain yield of 8.4 and 8.6 q/ha as compared to 7.5 and 8.8 q/ha of pearl millet in paired rows and uniform rows in pure stand whereas, cluster bean gave the additional seed yield of 2.4 and 3.2 q/ha, respectively (Sharma *et al.*, 1988) [36]. Out of three leguminous crops as intercrop, the cluster bean crop proved superiority over cowpea and green gram at Jobner, Rajasthan and gave 2.95 q/ha additional seed yield when two rows of cluster bean were sown in between paired rows of pearl millet (30:60 cm) with application of nitrogen at 30 kg/ha (Bhati and Manohar, 1989) [37].

Pearl millet and cluster bean grown in alternate rows (1:1) gave mean combined dry matter yield at par with sole cropping of pearl millet but significantly higher in the range of 42-194 per cent than mixed, intercropping and strip cropping. The 1:1 system also produced maximum grain yield among different intercropping systems (Singh and Joshi, 1994) [38]. Similarly, Singh *et al.* (2005) [39] observed that intercropping of one row of green gram and pearl millet in 30:70 cm paired row planting of cluster bean decreased the cluster bean yield by 24.7 and 24.1 per cent as compared to sole crop in paired row but produced additional yield of 2.22 and 8.35 q/ha of green gram and pearl millet, respectively.

The yield of sole pearl millet (1525 kg/ha) and from the crop intercropped with leguminous crops (1528, 1498, or 1540 kg/ha) were statistically the same and the yield from intercrop legumes was obtained as a bonus (Sharma and Gupta, 2001) [40]. Prasad and Nanwal (2001) [41] recorded significantly higher pearl millet grain equivalent yield (15.3 per cent) in pearl millet intercropping with mung bean as compared to sole pearl millet. Hooda *et al*. (2004) [42] observed that the grain and stover yield of pearl millet were statistically at par in both pearl millet + green gram intercropping system and sole pearl millet.

Inter or strip cropping of leguminous crops (green gram, cluster bean and cowpea) in 2:1 to 8:4 row ratio had no significant adverse effect on grain yield of pearl millet as compared to sole planting (Sharma and Singh, 2008) [43]. Ansari *et al.* (2011) [44] found that pearl millet + pigeon pea intercropping system recorded significantly higher pearl millet equivalent yield (4.31 and 4.82 t/ha, respectively) over the sole stand of component crops. Ansari *et al.* (2012) [45] also observed that pearl millet intercropped with pigeon pea recorded significantly higher pearl millet equivalent yield (PEY) as compared to either of sole cropping.

The highest yield attributes *viz*., grain weight per earhead (14.25 g), test weight (8.56 g), earhead diameter (3.13 cm), earhead length (14.25 cm) and earhead weight (31.15 g) of pearl millet were recorded in pearl millet + mung bean cropping system with 2:2 row ratio followed by pearl millet + mung bean cropping system in 2:1 row ratio, whereas, the maximum grain (1568 kg/ha), straw (5192 kg/ha) and biological yield (6760 kg/ha) were recorded in pearl millet sole crop as compared to intercropping treatments.

5. Intercropping assessment

There are number of ways of ensuring that intercropping advantages are accurately assessed, and the most common is the calculation of land equivalent ratio *i.e.* LER (Willey, 1979) [46]. Mead and Willey (1980) [47] pointed out that the LER of 1.2 indicated a yield advantage of 20 per cent. Rao and Willey (1980) [48] suggested that differences in maturity periods of the component crops usually resulted in quite higher yield. Better results of land use (LER) have been observed in the intercropping system than the sole crops (Ennin *et al.*, 2001; Adeniyan and Ayoola, 2006 and Muoneke *et al.*, 2007) [49-51]. Singh and Joshi (1980) [52] observed 21 per cent advantage in LER with double row of cluster bean planted in inter-row spaces of paired pearl millet (30/70 cm).

Patel *et al*. (1998) [53] found that based on net realization, benefit-cost ratio and LER, the pearl millet intercropped with cluster bean with a row ratio of 2:1 was superior among different intercropped treatments. Singh and Joshi (1994) [54] found that the pearl millet-green gram strip cropping (4:4) showed the highest land equivalent ratio of 1.26 indicating 26 per cent advantage over sole cropping. Sharma and Gupta (2001) [55] recorded the highest value of land equivalent ratio (1.21) for pearl millet + cluster bean cropping system, which gave significantly better results than the pearl millet + cowpea cropping system. Samba *et al*. (2007) [56] found that the pearl millet-cowpea intercropping system was more productive than their mono-crops as proved by the LER value of 1.2. Osman *et al*. (2011) [57] reported the LERs value larger than unity, indicating benefits of intercropping over sole cropping of millet.

Varia and Sadhu (2011) [58] observed the highest value of LER and relative crowding coefficient (RCC) for all the treatments of pearl millet intercropped with green gram than pearl millet sole and also observed that RCC was highest (3.47) in row ratio of 1:2 followed by RCC value of 2.04 under pearl millet + green gram in 1:1 ratio. Dwivedi *et al*. (2015) [59] observed that the pearl millet-cowpea intercropping was more productive than their mono-crops, which was proved through the LER value of 1.2.

The land equivalent ratio, area-time equivalent ratio, aggressively, competition ratio, monetary advantage index and crowding coefficient of green gram and cowpea in 8:4 and 6:3 strip cropping systems with pearl millet showed their superiority over other inter or strip cropping systems (Sharma and Singh, 2008) [60]. Singh *et al.* (2005) [61] reported that intercropping of both pearl millet and green gram in cluster bean was compatible as witnessed by higher values of biological parameters like land equivalent ratio, area time equivalent ratio, income equivalent ratio, monetary advantage index and crowding coefficient than sole cluster bean planting.

Kuri *et al.* (2012) [62] observed that the intercropping of pearl millet with moth bean in 1:7 row ratio closely followed by 4:4, 2:6 and 3:5 row ratio produced maximum pearl millet equivalent yield, LER and net returns as compared to sole and other intercropping treatments. Aggressively values showed that intercropping of moth bean did not offer any competition to pearl millet in different row ratio, while RCC values indicated that there was a yield disadvantage in moth bean in all the intercropping systems except 1:7 row ratio.

6. Economic returns

Alternate rows of cluster bean and pearl millet in 1:1 ratio gave significantly higher monetary returns than other intercropping systems, sole crop treatments and conventional systems of broadcasting of crop-mixtures (Singh, 1977) [63].

Singh and Joshi (1994a) [64] found the highest gross (Rs.7512/ha) and net returns (Rs. 5844/ha) with alternate row intercropping system (1:1) of pearl millet and guar, followed by sole cropping of pearl millet. Similarly, at RRS Bawal (Haryana), two rows of cluster bean sown in interspaces of pearl millet gave higher gross returns as compared to sole crop of pearl millet and even proved better than sole crop of cluster bean (Singh, 1981) [65]. Intercropping of 1 or 2 rows of cluster bean earned higher net returns without causing yield reduction in the base crop of pearl millet at Jobner (Sharma *et al.*, 1988) [66]. Among intercropping of pearl millet (*Pennisetum glaucum*) with green gram (*Vigna radiata*)/moth bean (*Vigna aconitifolia*) or cluster bean (*Cyamopsis tetragonoloba*) in 4:4, 4.3, 4:2, or 4:1 ratio, Singh (1994) [67] found the maximum net returns with moth bean in 4:1 ratio. Singh *et al.* (2003) [68] reported that intercropping of green gram with cluster bean paired row planting was more profitable than the other intercropping treatments in terms of cluster bean equivalent yield (17.7 q/ha), net return (Rs. 6846/ha) and income equivalent ratio (1.9).

Hooda and Khippal (2000) [69] recorded the highest gross as well net monetary returns of Rs. 19119 and 12270 per ha in pearl millet + green gram (30/60 cm) intercropping system. This system also recorded benefit-cost ratio of 2.75 which further witnessed the profitability of intercropping system. Hooda *et al*. (2004) [70] recorded higher gross (Rs. 24434/ha) as well as net monetary returns (Rs. 16043/ha) from the intercropping of pearl millet + green gram system which were higher by Rs. 3663 and 2923, respectively over sole pearl millet crop. Intercropping of pearl millet with green gram also recorded higher benefit-cost ratio of 1.90 which further witnessed the profitability of this system. Kumar *et al.* (2005) [71] also found that intercropping of guar in pearl millet gave more net returns (Rs. 6647) and benefit-cost ratio (1.98).

7. Conclusion

Based upon the literature cited above, it is concluded that the intercropping of pearl millet with pulses brought out earliness in phenological while the growth attributes (plant height, LAI, LAD, total tillers and dry matter accumulation per plant) and yield contributing traits (effective tillers per plant, earhead length, earhead girth and test weight) of pearl millet were decreased by the intercropping with different pulses. However, all the intercropping system in terms of pearl millet equivalent yield (PEY), the gross returns, net returns and benefit-cost ratio exhibited their superiority over their respective sole stands which in turns increasing farmer's income as compared to sole stand and reduce the risk of main crop failures.

8. References

1. Changmei S, Dorothy J. Millet - the frugal grain. International Journal of Scientific Research and Reviews. 2014; 3(4):75-90.
2. Ansari MA, Rana KS, Rana DS, Kumar A, Hariom. Effect of anti-transpirant and nutrient management on pearl millet (*Pennisetum glaucum*)-pigeon pea (*Cajanus cajan*) intercropping system under rainfed conditions. Indian Journal of Agronomy. 2012; 57(4):343-348.
3. Anonymous. Accessed from agricrop.nic.in. Department of Agriculture Cooperation and Farmer Welfare, 2016.
4. Yadav BL, Patel BS, Ali S, Yadav SK. Intercropping of legumes and oilseeds in summer pearl millet [*Pennisetum glaucum* (L.) R.Br. Emend. Stuntz]. Legume Research. 2015; 38(4):503-508.
5. Willey RW. A scientific approach to intercropping research. In: Proceedings of the International Workshop on Intercropping, Jan. 10th-13th, 1979, ICRISAT, Hyderabad, India, 1979.
6. Thakur NS, Pannase SK, Sharma RS. Production potential of gram based intercropping systems under rainfed condition. Indian Journal of Agronomy. 2000; 45(3):534-539.
7. Sobkowicz P. Competition between triticale and field beans in additive intercrops. Plant Soil Environment. 2006; 52:47-56.
8. Kaushik SK, Gautam RC. Effect of nitrogen and phosphorus on the production potential of pearlmillet-cowpea or green gram intcrcropping systems under rainfed conditions. Journal. 1987.
9. Enyi VAC. Grain yield in groundnut. Experimental Agriculture. 1977; 13:101-110.
10. Goswami VK, Kanshi SK, Gautam RC. Effect of intercropping and weed control on nutrient uptake and water use efficiency of pearl millet (*Pennisetum glaucum*) under rainfed condition. Indian Journal of Agronomy. 2002; 47(4):504-508.
11. Bhatnagar SK, Yadav OP, Gautam RC. Research achievements in pearl millet (*Pennisetum glaucum*). Indian Journal of Agricultural Sciences. 1998; 68:423-430.
12. Donald CM. Competition among crop and pasture plants. Advances in Agronomy. 1963; 15:1-118.
13. Aiyer AKYN. Principles of Crop Husbandry in India. Bangalore Press, 1967, 573.
14. Francis CA, Heicnel GH. Efficiency of energy production in maize, bean and other mixed cropping systems. Agronomy Abstracts. 1973, 72-73.
15. Kurdali F, Janat M, Khalifa K. Growth and nitrogen fixation and uptake in *Dhaincha*/Sorghum intercropping system under saline and non-saline conditions. Community of Soil Sciences and Plant Analysis. 2003; 34:2471-2494.
16. Gregorich EG, Drury CF, Baldock JA. Changes in soil carbon under long-term maize in monoculture and legume-based rotation. Canadian Journal of Soil Sciences. 2001; 81:21-31.
17. Gathumbi SM, Cadisch G, Buresh RJ, Giller KE. Subsoil nitrogen capture in mixed legume stands as assessed by deep nitrogen-15 placement. Soil Science Society of America Journal. 2003; 67:573-582.
18. Baldev R, Chaudhary GR, Jat AS, Jat ML. Effect of integrated weed management and intercropping systems on growth and yield of pear millet (*Pennisetum glaucum*). Indian Journal of Agronomy. 2005; 50(3):210-213.
19. Jensen ES. Grain yield, symbiotic N_2 fixation and interspecific competition for inorganic N in pea-barley intercrops. Plant and Soil. 1996; 182:25-38.
20. Anil J, Park R, Phipps H, Miller FA. Temperate intercropping of cereals for forage. Review of potential for growth and utilization with particular reference to the UK. Journal of Grass Forage Sciences. 1998; 53:301-317.
21. Siner J, Cox W, Shields E. Cropping system effects on weed emergence and densities in corn. Agronomy Journal. 2000; 92:754-760.
22. Deksen D, Anderson A, Blackshaw RE, Maxwell B. Weed dynamics and management strategies for cropping systems in the Northern Great Plains. Agronomy Journal. 2002; 94:174-185.
23. Jarenyama P, Hesterman OB, Waddington SR, Harwood RR. Relay-intercropping of sun hemp and cowpea into a small holder maize system in Zimbabwe. Agronomy Journal. 2000; 92:239-244.
24. Singh R, Khan MA. Response of cluster bean varieties to fertility levels and cropping systems under arid conditions. In: Advances in Arid Legumes Research (Eds. Henry, A., Kumar, D. and Singh, N.B.). Scientific Publishers, Jodhpur (India), 2003, 225-228.
25. Misra P. Studies on intercropping of pearl millet [*Pennisetum glaucum* (L.) R. Br.] with cluster bean

[*Cyamopsis tetragonoloba* (L.) Taub.] under dryland conditions. M.Sc. Thesis, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, 1996.
26. Yadav BL, Patel BS, Ali S, Yadav SK. Intercropping of legumes and oilseeds in summer pearl millet [*Pennisetum glaucum* (L.) R.Br. Emend. Stuntz]. Legume Research. 2015; 38(4):503-508.
27. Baldev R, Chaudhary GR, Jat AS, Jat ML. Effect of integrated weed management and intercropping systems on growth and yield of pear millet (*Pennisetum glaucum*). Indian Journal of Agronomy. 2003; 48(4):254-258.
28. Baldev R, Chaudhary GR, Jat AS, Jat ML. Effect of integrated weed management and intercropping systems on growth and yield of pear millet (*Pennisetum glaucum*). Indian Journal of Agronomy. 2005; 50(3):210-213.
29. Ansari MA, Rana KS, Rana DS, Kumar A, Hariom. Effect of anti-transpirant and nutrient management on pearl millet (*Pennisetum glaucum*)-pigeon pea (*Cajanus cajan*) intercropping system under rainfed conditions. Indian Journal of Agronomy. 2012; 57(4):343-348.
30. Singh BP, Rana VS, Yadava BS. Intercropping of mung bean and cluster bean in pearl millet and urd bean in cluster bean in rainfed conditions. *Pulse Crops Newsletter*. 1981; 1(4):35-36.
31. Anjeneyula VR, Singh SP, Ali M. Effect of competition free period and technique and pattern of pearl millet planting in growth and yield of mung bean and total productivity in solid pearl millet and pearl millet/mung bean intercropping systems. Indian Journal of Agronomy. 1982; 2**7**(3):219-226.
32. Singh BP. Effect of inter cropping with pearl millet on productivity, profitability and water use on aridisols. Indian Journal of Agronomy. 1985; 30(4):408-413.
33. Rana VS, Faroda AS, Dahiya SK, Yadav BS. Effect of mixed intercropping of mung bean and clusterbean in bajra under rainfed conditions. Haryana Agricultural University Journal of Research. 1986; 16(1):71-76.
34. Kaushik SK, Gautam RC. Effect of nitrogen and phosphorus on the production potential of pearlmillet-cowpea or green gram intcrcropping systems under rainfed conditions. Journal, 1987.
35. Sharma KB, Singh GD, Keshwa GL. Yield and return of pearl millet and cluster bean intercropping as affected by nitrogen in semi-arid areas. Haryana Journal of Agronomy. 1988; 4:135-137.
36. Bhati DS, Manohar SS. Studies on the intercropping of pearl millet with legumes at two nitrogen levels. Haryana Journal of Agronomy. 1989; 5:9-12.
37. Singh M, Joshi NL. Effect of mixed and intercropping systems on dry matter and grain yields of companion crops in arid environment. Annals of Arid Zone. 1994; 33:125-128.
38. Singh J, Kumar A, Singh B. Additive series intercropping system in cluster bean and green gram under rainfed conditions of south west Haryana. Haryana Journal of Agronomy. 2005; 21(2):101-103.
39. Sharma OP, Gupta AK. Comparing the feasibilities of pearl millet-based intercropping systems supplied with varying levels of nitrogen and phosphorus. Journal of Agronomy and Crop Sciences. 2001; 186(2):91-95.
40. Prasad J, Nanwal RK. Nutrient content and uptake studies in pearl millet (*Pennisetum glaucum*) intercropping system under rainfed conditions. Haryana Journal of Agronomy. 2001; 17(1, 2):193-195.
41. Hooda RS, Khippal A, Narwal RP. Effect of fertilizer application in conjunction with bio-fertilizers in sole and intercropping systems of pearl millet under rainfed condition. Haryana Journal of Agronomy. 2004; 20(1):29-30.
42. Sharma SK, Singh J. Pearl millet (*Pennisetum glaucum*)-legume compatibility in inter and strip cropping system under rainfed conditions. Indian Journal of Agricultural Sciences. 2008; 78(4):355-357.
43. Ansari MA, Rana KS, Rana DS, Kumar P. Effect of nutrient management and anti-transpirant on rainfed sole and intercropped pearl millet (*Pennisetum glaucum*) and pigeon pea (*Cajanus cajan*). Indian Journal of Agronomy. 2011; 56(3):209-216.
44. Ansari MA, Rana KS, Rana DS, Kumar A, Hariom. Effect of anti-transpirant and nutrient management on pearl millet (*Pennisetum glaucum*)-pigeon pea (*Cajanus cajan*) intercropping system under rainfed conditions. Indian Journal of Agronomy. 2012; 57(4):343-348.
45. Willey RW. A scientific approach to intercropping research. In: Proceedings of the International Workshop on Intercropping, Jan. 10th-13th, 1979, ICRISAT, Hyderabad, India, 1979.
46. Mead R, Willey RW. The concept of 'Land Equivalent Ratio' and advantages in yield from intercropping. Experimental Agriculture. 1980; 16:217-218.
47. Rao MR, Willey RW. Preliminary studies of intercropping combination based on pigeon pea or sorghum. Experimental Agriculture. 1980; 16:29-40.
48. Ennin SA, Asafu-Agyei JN, Dapoah HK, Ekyem SA. Cowpea rotation with maize in cassava-maize intercropping systems. Tropical Agricultural. 2001; 78:218-225.
49. Adeniyan ON, Ayoola OT. Growth and yield performance of some improved soybean varieties as influenced by intercropping with maize and cassava in two contrasting locations in Southwest Nigeria. African Journal of Biotechnology. 2006; 5:1886-1889.
50. Muoneke CO, Ogwuche MAO, Kalu BA. Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agro-ecosystem. African Journal of Agricultural Research. 2007; 2:667-677.
51. Singh P, Joshi NL. Intercropping of pearl millet in arid areas. Indian Journal of Agricultural Sciences. 1980; 50:338-341.
52. Patel MR, Kalyanasundaram NK, Patel IS, Patel JM, Patel SI, Patel BM *et al*. Effect of additive and replacement series in intercropping system with pearl millet. Annals of Arid Zone. 1998; 37(1):69-74.
53. Singh M, Joshi NL. Effect of mixed and intercropping systems on dry matter and grain yields of companion crops in arid environment. Annals of Arid Zone. 1994; 33:125-128.
54. Sharma OP, Gupta AK. Comparing the feasibilities of pearl millet-based intercropping systems supplied with varying levels of nitrogen and phosphorus. Journal of Agronomy and Crop Sciences. 2001; 186(2):91-95.
55. Samba T, Coulibay BS, Kone A, Bagayoko M, Kouyate Z. Increasing the productivity and sustainability of millet based cropping systems in the Sahelian zones of West Africa. In: Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities (Ed. Bationo, A.). 2007, 567-574.

56. Osman AN, Raebild A, Christiansen JL, Bayala J. Performance of cowpea (*Vigna unguiculata*) and pearl millet (*Pennisetum glaucum*) intercropped under *Parkia biglobosa* in an agro forestry system in Burkina Faso. African Journal of Agricultural Research. 2011; 6(4):882-891.
57. Varia SD, Sadhu AC. Effect of row ratios and fertility levels on productivity of pearl millet (*Pennisetum glaucum*)-green gram intercropping system under middle Gujarat conditions. Haryana Journal of Agronomy. 2011; 27(1, 2):68-70.
58. Dwivedi A, Dev I, Kumar V, Yadav RS, Yadav M, Gupta D *et al*. Potential role of maize-legume intercropping systems to improve soil fertility status under smallholder farming systems for sustainable agriculture in India. International Journal of Life Sciences Biotechnology and Pharmacy Research. 2015; 4(3):164-169.
59. Sharma SK, Singh J. Pearl millet (*Pennisetum glaucum*)-legume compatibility in inter and strip cropping system under rainfed conditions. Indian Journal of Agricultural Sciences. 2008; 78(4):355-357.
60. Singh J, Kumar A, Singh B. Additive series intercropping system in cluster bean and green gram under rainfed conditions of south west Haryana. Haryana Journal of Agronomy. 2005; 21(2):101-103.
61. Kuri BR, Yadav RS, Kumawat A. Evaluation of pearl millet (*Pennisetum glaucum*) and moth bean (*Vigna acconitifolia*) intercropping systems in hyper arid partially irrigated north-western plains zone. Indian Journal of Agricultural Sciences. 2012; 82(11):993-996.
62. Singh RP. Studies on intercropping in guar. Annual Report Kharif 1977. Dryland Agriculture Main Centre, Jodhpur, India, 1977.
63. Singh M, Joshi NL. Performance of pearl millet based intercropping system under drought conditions. Arid Soil Research Rehabilitation. 1994a; 8:313-319.
64. Singh BP. Effect of inter cropping of guar in pearl millet. Guar Newsletter. 1981; 2:24-27.
65. Sharma KB, Singh GD, Keshwa GL. Yield and return of pearl millet and cluster bean intercropping as affected by nitrogen in semi-arid areas. Haryana Journal of Agronomy. 1988; 4:135-137.
66. Singh R. Pearl millet based intercropping in arid zone of Rajasthan. Annals Arid Zone. 1994; 33(2):155-156.
67. Singh J, Kumar A, Singh B. Production potential and economics of cluster bean under various geometries and intercropping systems. In: Advances in Arid Legumes Research, Jodhpur (India), 2003, 207-211.
68. Hooda RS, Khippal A. Comparative performance of different intercropping systems in pearl millet in relation to nutritional requirements. Haryana Journal of Agronomy. 2000; 16(1, 2):70-72.
69. Hooda RS, Khippal A, Narwal RP. Effect of fertilizer application in conjunction with bio-fertilizers in sole and intercropping systems of pearl millet under rainfed condition. Haryana Journal of Agronomy. 2004; 20(1):29-30.
70. Kumar A, Singh J, Singh B, Yadav YP. Effect of additive series intercropping in pearl millet in relation to nutritional requirement under rainfed conditions. Haryana Agricultural University Journal of Research. 2005; 35:113-117.