Indian J. Dryland Agric. Res. & Dev. 2022 37(2): 99-102 10.5958/2231-6701.2022.00023.9

Overview of Dryland Agriculture Research and Achievements in South-western Dry Zone of Haryana

S.K. Thakral[1], S.K. Sharma[1], Manjeet[1], Rakesh Kumar[1] , B. Rajkumar[2] and Abdul Rasul[2]

[1]*All India Coordinated Research Project for Dryland Agriculture, Hisar, 125 004, Haryana*

[2]*All India Coordinated Research Project for Dryland Agriculture, ICAR-CRIDA, Hyderabad - 500 059*

Brief history of the Centre

Hisar centre of All India Coordinated Research Project on Dryland Agriculture started in June, 1971 . Subsequently, an Operational Research Project was started at under AICRPDA in 1984 for on-farm research i.e. testing, refining and transfer of technologies. The project undertook experiments to generate location specific technologies focusing on rainwater management, cropping systems, nutrient management, energy management, evaluation of improved varieties and alternate land use systems.

Agro-climatic zone characteristics

All India Co-ordinated Research Project for Dryland Agriculture, Hisar centre is located at Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. The climate in the zone is sub-tropical and monsoonal type with prolonged hot period from March-October and fairly cool winters. The normal onset of monsoon in the zone is during first week of July and normal withdrawal is during third week of September. Average annual rainfall in the zone is about 425.5 mm (*kharif* with 337.8 and *rabi* with 54.9). Major portion (75-80%) of the annual rainfall is received in June-September. The mean maximum and minimum temperatures in the zone are 48 °C and 1-2 °C, respectively. Intermittent dust storms are also common in the region. The dry spells had been experienced during *kharif* season coinciding with seedling, vegetative and reproductive stages of the major rainfed crops. In the post monsoon winter season, few light showers (15-20% of annual) are received from westerly depressions.

Mean season-wise and annual rainfall and rainy days at AICRPDA centre, Hisar

Rainfall	Normal rainfall (mm)	Normal rainy days
South west monsoon (June-September)	337.8	17
Post-monsoon (October-December)	16.5	1
Winter (January-February)	25.4	3
Summer (March-May)	48.8	3
Annual	**425.5**	**24**

Major soil types

The major soil types in the zone are loamy sand to sandy loam in surface and sandy loam to loamy in sub-surface layers. About 72% and 28% area comes under loamy sand and sandy loam soil in the domain area of the zone.

Major rainfed crops

The major rainfed crops cultivated in the zone during *kharif* are greengram, pearl millet, clusterbean, and during *rabi* are mustard and chickpea.

Dryland agriculture problems

- Light soil texture: Soils in dryland areas are light textured with undulating topography and have poor water retention capacity.
- Poor soil fertility: Soils in these areas are light textured, poor in organic C and consequently poor in all major and micro-nutrients.
- Poor socio-economic conditions of the farmers and low adoption of developed technologies.

Significant achievements

Rainwater management

- The maximum net returns of Rs. 12890 ha^{-1} with BC ratio of 1.81 from a yield of 1030 kg ha^{-1} were attained when greengram was sown across the slope in *kharif*.
- Deep ploughing before the onset of monsoon was superior and gave a maximum and significantly higher mustard yield of 2556 kg ha^{-1}, net income of Rs.29594 ha^{-1}
- The highest grain yield of pearl millet was obtained with pond silt @ 60 t ha^{-1} (1276 kg); and N 60 + P_2O_5 30 kg ha^{-1}(1402 kg), respectively. The maximum seed yield (1945 kg ha^{-1}) of mustard was obtained with pond silt @ 60 t ha^{-1} and N 60 + P_2O_5 30 kg ha^{-1}.
- Maximum grain yield of pearl millet and mustard were recorded in RDF + two sprays of Thiourea (2701 kg ha^{-1}) and (2548 kg ha^{-1}) followed by RDF + 1% KNO3 (2500 kg ha^{-1}) and (2489 kg ha^{-1}), resulting in higher net return and B:C ratio. These treatments were significantly higher than RDF + No spray and RDF + Water spray 2.
- Supplemental irrigation (25 mm) from harvested rain water in farm pond to pearlmillet gave higher pearlmillet equivalent yield (2177 kg ha^{-1}), net returns (17704 ha^{-1}), B:C ratio

(1.95) and RWUE (10.78 kg ha^{-1}mm^{-1}) compared to without supplemental irrigation (1976 kg ha^{-1}). Similarly, greengram recorded significantly higher pearl millet equivalent yield (2133 kg ha^{-1}), than pearl millet (2020 kg ha^{-1}).

- In intra-plot rainwater harvesting, maximum pearl millet equivalent yield of 2860 kg ha^{-1} was observed with green gram under 75% slope and 2/3rd donor area and the lowest pearl millet equivalent yield of 1526 kg ha^{-1} was obtained by pearl millet under 1.5% slope ½ donor area.

Cropping systems

- Castor paired rows (60-120-60 cm) + two rows of greengram was superior with maximum castor equivalent yield of 1030 kg ha^{-1}, net income of Rs. 7057 ha^{-1} and B:C ratio of 1.45.
- Mothbean in paired rows (30-60 cm) + one row of clusterbean was superior with significantly higher mothbean equivalent yield of 1154 kg ha^{-1}, net income of Rs.11891 ha^{-1} and B:C ratio of 1.81.
- Chickpea as sole crop at 30 cm spacing gave significantly higher chickpea grain equivalent yield (1948 kg ha^{-1}). Inter/strip cropping of chickpea + barley in 2:1, 4:2 and 6:3 ratios did not significantly increase chickpea equivalent yield over sole chickpea. Highest B:C ratio was attained under chickpea + barley (6:3).
- Pearlmillet + mungbean (8:4 row ration) was superior with maximum pearlmillet equivalent yield of 2756 kg ha^{-1}, net income of Rs. 9641 ha^{-1} and BC ratio of 1.67.
- Grain yield of *Sesbania* was recorded highest (1054 kg ha^{-1}) in *Sesbania* sole at 60 cm. Grain yield of pearl millet was recorded highest (1778 kg ha^{-1}) in pearl millet sole at 45 cm spacing. *Sesbania* + pearl millet intercropping gave negative net return due to excessive vegetative growth of *Sesbania* at initial stage of crop.

Integrated nutrient management

- Application of 60 kg N + 20 kg P ha^{-1} was superior with a significantly higher castor yield of 1066 kg ha^{-1}, and 20 kg N + 40 kg P ha^{-1} was superior with significantly higher moth bean yield of 932 kg ha^{-1}.
- Application (60 kg N 30 kg P_2O_5 and 20 kg K_2O/ ha) gave yield of 2063 kg ha^{-1} in pearl millet and 3070 kg ha^{-1}, net return Rs. 37529 ha^{-1} and B:C ratio of 2.50 in mustard.
- Application 40 kg N + 20 kg P ha^{-1} at sowing time was superior with barley yield of 4153 kg ha^{-1} and 20 kg N + 40 kg P ha^{-1} + inoculation with biomix gave significantly higher chickpea yield of 1196 kg ha^{-1} net income of Rs. 14393 ha^{-1} and BC ratio of 1.94.
- In a study on the effect of foliar spray of nutrients on yield and economics of clusterbean during *kharif,* application of recommended dose of fertilizer (20:40 NP kg ha^{-1}) + foliar spray of NPK (0:0:50) 1% + 0.5% $ZnSO_4$ at flower initiation recorded significantly higher seed yield (885 kg ha^{-1}) and stover yield (1776 kg ha^{-1}) compared to other treatments except RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation, RDF + $ZnSO_4$ spray at flower initiation and RDF + $ZnSO_4$ at pod formation. Higher net returns (Rs.19046 ha^{-1}), BC ratio (1.97) and RWUE (2.84 kg ha^{-1}mm^{-1}) were also recorded with application of recommended dose of fertilizer (20:40 NP kg ha^{-1}) + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation compared to other treatments.

Energy management

- Significantly higher pearl millet yield of 2116 kg ha^{-1}, net returns of Rs.7058 ha^{-1} and B:C ratio of 1.44 were attained by low tillage + two intercultures + 100% N (inorganic) application.
- Ridger seeder (2 rows) was superior with significantly higher mustard seed yield of 2197 kg ha^{-1}, net returns of Rs.29478 ha^{-1} and BC ratio of 2.74 under normal moisture condition; and seed yield of 1731 kg ha^{-1}, net returns of Rs.19630 ha^{-1} and BC ratio of 2.16 under receding moisture condition.

Technologies developed

Cropping systems

a. Intercropping systems

- Pearl millet + greengram (8:4)
- Pearl millet + clusterbean (8:4)
- Pearl millet + cowpea (8:4)
- Castor paired 60:120 cm x 60 cm + 2 rows of blackgram
- Castor paired 60:90 cm x 60 cm + 1 row of blackgram
- Moth bean paired row 30:60 cm + 1 row of cluster bean

Double cropping system

- Pearl millet - chickpea
- Pearl millet - raya
- Greengram - raya

Integrated nutrient management practices

Crop	INM practice
Pearl millet	N (30 kg ha^{-1}) + P_2O_5 (15 kg ha^{-1}) + *Azatobacter* + FYM (4 t ha^{-1})/ vermicompsot @ 2 t ha^{-1}
Cluster bean	N (15 kg ha^{-1}) + P_2O_5 (30 kg ha^{-1}) + *Rhizobium* + PSB + FYM (4 t ha^{-1})/ vermicompsot @ 2 t ha^{-1}
Greengram	N (15 kg ha^{-1}) + P_2O_5 (30 kg ha^{-1}) + *Rhizobium* + PSB + FYM (4 t ha^{-1})/ vermicompsot @ 2 t ha^{-1}
Mustard	N (30 kg ha^{-1}) + P_2O_5 (30 kg ha^{-1}) + *Azatobacter* + FYM (4 t ha^{-1})/ vermicompsot @ 2 t ha^{-1}
Chickpea	N (30 kg ha^{-1}) + P_2O_5 (30 kg ha^{-1}) + *Rhizobium* + FYM (4 t ha^{-1})/ vermicompsot @ 2 t ha^{-1}

Foliar nutrition

- Foliar spray of water soluble complex fertilizer N:P:K (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5% should be practised in pearl millet as well as mustard crop during the dry spell of the crop.

Energy management

- Improved ridger seeder places seeds and fertilizer in single operation and sowing seeds of pearl millet at appropriate depth (3-4 cm) in the moist zone on the shoulders of the ridges for overcoming problem of seed burying with extra soil cover. This results in better germination. It can be used for *rabi* crops with better results. It makes furrows by removing the dry soil and places the seeds in furrows with adequate moisture. It forms ridges of 30 cm wide and 15 cm height. Depth of sowing can be adjusted. Improved technology gave yield of 2640 ha^{-1}, net returns of Rs.80127 ha^{-1}, B:C ratio of 3.90 and RWUE of 61.51 kg $ha^{-1}mm^{-1}$ when compared to farmers practice (2284 ha^{-1}).
- Harrowing with tractor drawn disc harrow in *kharif* is more effective for *in-situ* moisture conservation, which results in raising better chickpea crop in *rabi*. Harrowing is done after each effective rainfall event of >15 mm. Disc harrow pulverizes soil to deeper layers for better infiltration of rainwater into the soil profile. Sowing of chickpea (C-235) is done in second fortnight of October with bullock or camel drawn country plough. The cost of this harrow is Rs.25000 and cost of harrowing is Rs.500 ha^{-1}. A significantly higher chickpea seed yield of 965 kg ha^{-1} was realized when disc harrowing is done during *kharif*, which is 44 % higher than farmers practice.

Contingency crop planning

For *kharif* planning

a. Suggested contingency crops/ cropping systems and cultivars under delayed onset of monsoon

Delay by 2 weeks (3rd week of July)

- Pearl millet hybrids (HHB-67 (Improved), HHB 197, HHB 272, HHB 226); clusterbean (HG 563, HG 365, HG 2-20); greengram (MH 421, MH 318)
- Intercropping systems: Pearl millet (HHB-67(Improved) + greengram (MH 421) (8:4)

Delay by 4 weeks (1st week of August)

- Pearl millet (HHB-67 (Improved), HHB 197, HHB 272, HHB 226) can be sown latest by first week of August
- Pearl millet (HHB-67 Improved); clusterbean (HG 365); greengram (MH-421)
- Thinning to reduce 1/3rd population should be done in timely sown crop
- Sowing of clusterbean (HG 563, HG 365, HG 2-20) may be ensured by end of July and pulses by first week of August with early maturity varieties

Delay by 6 weeks (3rd week of August)

- Transplant pearl millet hybrid HHB-67 (improved)
- Avoid sowing of clusterbean and conserve the moisture for *rabi* sowing. However, some area may be used for fodder (cowpea/greengram)
- Do not prefer sowing of sesame beyond mid-August.

Delay by 8 weeks (3rd week of August)

- Keep land fallow
- Conserve moisture for *rabi* crops

b. Crop, soil, water and nutrient management strategies during seasonal drought

Early season drought

- In pearl millet, if the plant stand is less than 60 %, go for resowing as and when rains resume and gap filling by transplanting under rainy conditions
- After receiving 25-50 mm of rainfall, 2 to 3 ploughings to be done using cultivator followed by sowing
- One interculture operation for removing weeds and better moisture conservation
- Avoid fertilizer application, if effective rainfall received at a later period. Apply second half (20 kg N ha^{-1}) as top dressing at knee high stage (25-30 DAS) in pearl millet.
- Practice of intercropping (strip cropping of greengram in 8:4 at 30 cm row spacing with pearl millet as main crop.

Mid-season drought

- Open conservation furrows and ridge and furrow for rainwater harvesting
- Straw mulching in between rows
- Frequent interculture; weeding and hoeing with wheel hand hoe/kasola
- In pearl millet, harvest every third row for green fodder and make ridge and furrow for *in-situ* rainwater harvesting; weeding and hoeing with wheel hand hoe/kasola as and when required
- Provide life-saving irrigation (4-5 cm), if possible
- Foliar spray of water-soluble complex fertilizer (18:18:18) @ 0.5% + 0.5% $ZnSO_4$ in pearl millet during dry spell
- Avoid chemical weed control

Terminal drought

- Remove every third row of pearl millet for green fodder.
- Provide life-saving irrigation, if available.

- Harvesting of intercrop at physiological maturity (greengram)
- Field preparation for *rabi* crop sowing during first fortnight of October
- Sowing of mustard (RH 30, RB 50, RH 725, RH 119, RH 406, RH 761) and chickpea (HC 1) during second fortnight of October.

For *rabi* planning

a. Suggested crops and varieties for delayed season

- Mustard (RH 30, RB 50, RH 406, RH 725, RH 761) and chickpea (HC 1).
- Foliar spray of water-soluble complex fertilizer (18:18:18) @ 0.5% + 0.5% $ZnSO_4$ in mustard during dry spell.

Agro-hortisystems

- Jandi (Local) + greengram (MH 421) ; spacing for jandi (6*6 m) and greengram (45 x 10 cm)
- Ber (Gola, Seb, Illachi, Kaithli) + greengram (MH 421); spacing for ber (10 x 10 m) and greengram (45 x 10 cm).

Impact of technologies

Pearl millet (cv. HHB-67) hybrid gives 20 per cent higher grain yield (2975 kg ha^{-1}) with B:C ratio of 1.68 as compared to existing hybrids i.e. HHB 50 (2475 kg ha^{-1}) and HHB 60 (2719 kg ha^{-1}). Even under low rainfall and light textured soils, HHB-67 gives a yield of 1284 kg ha^{-1}, which is 20% more than HHB-50 (1090 kg ha^{-1}). Strip cropping of pearl millet + greengram (8:4) for higher productivity in Western Dry Zone of Haryana. Strip cropping of pearl millet + greengram (8: 4) gives a pearl millet equivalent yield of 3196 kg ha^{-1}, net income of Rs. 23732 ha^{-1} and B:C ratio of 2.26. This practice ensures some yield advantage during drought years. In case of early drought, pearl millet can survive but legumes cannot whereas, while under terminal drought situation, the performance of pearl millet is risky. Thus, this technology provides an opportunity of realizing good yields and income to the farmers from either of the crops in case of weather aberration.

Nutrient management for higher productivity of pearl millet in South-western Dry Zone of Haryana. The improved practice gives a grain yield of 1843 kg ha^{-1} compared to 716 kg ha^{-1} under farmers' practice. An additional income of Rs.535 ha^{-1} with B:C ratio of 3:1 can be achieved through nutrient management. This improved practice has been adopted on 189000 ha, i.e, 30% of pearl millet area in Haryana. Harrowing with tractor drawn disc harrow is practiced in 45000 ha in south-western district of Haryana. A significantly higher chickpea seed yield of 965 kg ha^{-1} is realized when disc harrowing is done during *kharif*, which is 44% higher than farmers practice. An additional net return of Rs. 4000 ha^{-1} with a B:C ratio of 1.42 can be realized with disc harrowing. Improved ridger seeder for planting rainfed crops in Southern Dry Zone of Haryana. Sowing with ridger seeder saves 15% seed, 60% on labour and operating time and 45% in cost of sowing. Pearl millet grain yield can increase up to 23%, giving an additional net returns of Rs.1400 ha^{-1} with a B:C ratio up to 2.34.