Annual Progress Report: 2017-18

2. Agronomy

Contents

2. Agronomy

Executive summary

During *Kharif* - *Rabi* 2017-18, field experiments were conducted at different AICRP Small Millets centers to evaluate pre- released small millet genotypes under different fertility levels, nutrient, weed management, drought mitigation strategies and millet based cropping systems for increased productivity and profitability.

Evaluation of pre- released genotypes to fertility levels

- 100 per cent recommended dose of fertilizer was found optimum to realize higher yields in Finger millet, Foxtail millet, Little millet and Barnyard millet
- The test variety VL 386 (Finger millet), SiA 3156 and test variety DHFT 5-6 (Foxtail millet), OLM-203, BL 6 and DLM 95 (Little millet) were found superior to other varieties tested in respective centre respectively.

Nutrient management in small millets

- Seed pelleting with biofertilizers, micronutrients along with 100 per cent RDF application was found best to enhance finger millet production
- Under irrigated condition, application of 75 and 100 per cent recommended dose of fertilizers through briquettes improved productivity and profitability of finger millet
- Either 50 percent N through FYM and 50 percent N through Poultry manure or application of 100 percent N through poultry manure resulted in enhancing higher productivity in finger millet under rain fed condition
- For finger millet (rainfed and irrigated), foxtail millet, proso millet and barnyard millet, the integration of organic and inorganic *i.e.,* INM was found better followed by application of inorganic only.

Assessing the performance of small millets to different sowing windows

- Normal sowing was found best for Kodo, little, foxtail and barnyard millet followed by early sowing
- Need based agronomic management practices are necessary to tackle mid and late season drought to increase productivity and moisture conservation
- Sowing date from 4th week of June to 2nd week of July was found ideal for finger millet in Kolhapur.

Weed management for small millets

- Standard cultural practice *i.e.,* two inter cultivations along with one hand weeding improved finger millet productivity and the best chemical weed management practice was pre emergence application of Isoproturon @ 0.5 kg a.i. / ha along with one intercultivation for rainfed condition and pre emergence application of Oxyflurofen @ 0.10 lit a.i/ha along with one intercultivation for irrigated condition
- Under irrigated finger millet in Karnataka, either pre emergent weedicide Butachlor 50 EC 750 g a.i./ha or post emergent weedicide Ethoxysulfuron15 WG 15g a.i /ha with one intercultivation was found good.

Millet based cropping systems for sustainable productivity

- Production of millets through inter/sequence cropping with legumes improve the productivity of whole system (crop and soil)
- Finger millet + Guar (8:2), Finger millet + Bhendi (8:2), Finger millet + Amaranthus (90:10 by weight), Foxtail millet + Redgram(5:1), Little millet + Niger (4:1), Barnyard millet + Niger(4:1) and cropping sequence Barnyard millet + Rice bean (90:10) - wheat are possible intercropping systems and cropping sequence for enhancing crop productivity and profitability.

Detailed report

2.1. Evaluation of pre- released genotypes to fertility levels

At Almora, Athiyandal, Bengaluru, Nandyal, Dindori, Jagadalpur, Kanke, Kolahapur, Ranichauri, Vizianagaram and Waghai, field experiments were conducted to evaluate the response of pre-released genotypes of small millets to fertility levels. Results revealed that the grain yield and economics of genotypes varied with locations and fertility levels (Table 2.1.1 to 2.1.5).

2.1.1. Finger millet

Fertility levels: The application of 100 per cent recommended dose of fertilizer (RDF) gave higher grain yield (2417 kg/ha) and B: C ratio (1.71) which are found significantly higher than grain yield (2095 kg/ha) and B:C ratio(1.45) obtained with the application of 75 per cent RDF. Whereas, the straw yield was found significantly higher at application of 125 per cent RDF treatment (5599 kg/ha) than with the application of 75 per cent RDF. Similar results were obtained at Ranichauri for grain yield, straw yield and B:C ratio. Whereas, at centers Vizianagarum and Waghai, the grain yield was found to be significantly higher at application of 125 per cent RDF than other fertility levels (Table 2.1.1).

Performance of Varieties: The test variety VL 386 was observed to be significantly superior over national check varieties VL 352 (13%) and GPU 45 (14%) for grain yield and B:C ratio however it was found on par with the local check. The test variety also surpassed significantly over other varieties at Ranichauri and Vizianagaram centers whereas, the local check was found significant among all varieties for grain yield and B:C ratio at center Waghai. For straw yield, the local check was found significantly higher than test variety and national check VL 352 but was found on par with other national check variety GPU 45. Interaction between pre released genotypes and fertility levels were found non significant (Table 2.1.1).

2.1.2. Foxtail millet

Fertility levels: Among different fertility levels, higher grain yield (1860 kg/ha) and B: C ratios (2.47) were observed with the application of 125 per cent RDF and which were closely followed by application of 100 per cent RDF. The lowest grain yield (1427 kg/ha) with B:C ratio(1.96) were found with the application of 75 per cent of RDF (Table 2.1.2).

Performance of Varieties: The check variety SiA 3156 recorded significantly higher grain yield (1779 kg/ha) along with higher B:C ratio (2.36) as compared to other varieties apart from test variety DHFT 5-6. The check variety SiA 3156 at Nandyal and test variety DHFT 5-6 at Athiyandal have performed significantly superior for grain yield, straw yield and B:C ratios as compared to other varieties. Interaction between pre released varieties and fertility levels showed non significant response (Table 2.1.2).

2.1.4. Little millet

Fertility levels: The fertility levels showed significant response for grain yield and economics. Significantly higher grain yield and B:C ratios were obtained at the application of 125 per cent RDF and which were calculated to 37.73 and 39.06 per cent higher grain yield and B:C ratio, respectively than with the application of 75 per cent RDF. However, grain, straw yield and B:C ratios of 125 and 100 application of RDF fertility levels were found on par with each other. Similar results were obtained at centers Dindori, Jagdalpur and Kanke. The grain yield at application of 125 per cent was significantly higher than 75 and 100% RDF at Kolhapur centre (Table 2.1.4).

Performance of Varieties: Varieties showed significant response for grain yield, yield related parameters and B:C ratios. The check OLM-203 has performed well followed by check BL 6 and test variety DLM 95. At Dindori, variety DLM 95 was significantly higher as compared to rest of all varieties. However, variety BL 6 at Jagadalpur, national check (JK-8) at Kanke and check (OLM-203) at Kolhapur have showed significant response for grain yield thus showing varied response of varieties at different centers (Table 2.1.4). The straw yield of check BL 6 at Jagdalpur and Kanke and test variety DLM 95 at Dindori and check OLM 203 at Kolhapur were found significantly superior over other varieties. However, varieties showed non significant responses for B:C ratio. Further, interaction between genotypes and fertility levels showed non significant response for above parameters discussed.

2.1.5. Barnyard millet

Fertility Levels: There is a significant difference for grain yield and B:C ratios with different fertility levels. 125 percent RDF application recorded significantly higher grain yield (38.11%) and B:C ratio (37.75%) as compared to 75 per cent RDF application. However, fertility level 150 per cent RDF was found on par with 100 per cent RDF. Similar results were obtained at Bangalore. At centers, Athiyandal and Jagadalpur, 150 per cent has recorded significantly higher grain yield and B:C ratios than other two fertility levels. Whereas, 100 per cent RDF was found significantly superior over other two fertility levels at Ranichauri (Table 2.1.5).

Performance of varieties: At all India level, national check VL172 gave highest grain yield of 1990 kg/ha followed by variety VL 249 (1874 kg/ha). National check (VL172) at Almora was found having significantly higher grain yield (201%) as compared to DHBMV 23-3. Variety VL249 at Athiyandal (39% over DHBMV23-3) and Ranichauri (20% over national check VL207) have also shown significant responses. In contrary, DHBMV 23-3 at Bangalore has shown significantly higher grain yield as compared to VL 249(43%), VL 172 (17%) and VL 2017 (20%). The similar trend was observed with B:C ratios at all centers (Table 2.1.5). The interaction between genotypes and fertility levels exhibited insignificant response.

2.2. Nutrient management in small millets

2.2.1. Studies on seed palleting with biofertilizer and micronutrients

An experiment was conducted at Kanke to know the effect of seed coating of biofertilizer *Viz., Azospirillium brasilience*, *Bacillus megathelium* and *Pseudomonas fluroscence* along with micronutrients Zinc sulphate and boron @ 3 g/kg seed were evaluated at different fertility levels 50, 75 and 100 per cent RDF. The data on growth, yield and economics were presented in Table 2.2.1. Results indicated that the application of 100 per cent RDF, micronutrients and seed treatment with biofertilizers gave significantly higher grain yield (2328 kg/ha) which was found to be 128 and 59 per cent higher than absolute control and application of recommended dose of FYM only (7.5 t/ha), respectively. The straw yield also showed the similar pattern.

2.2.2. Studies on efficient fertilizer management in finger millet under irrigated condition

For finding an efficient fertilizer management in finger millet under Irrigated condition, an experiment was laid out at Mandya during 2017 under irrigated condition (Table 2.2.2). Significantly higher grain (4563 kg/ha) and straw yield (6107 kg/ha) were observed with the application of application of recommended dose of FYM (5.0 t ha^{-1}) + Fertilizers (100:50:50 kg $NP_2O_5K_2O$ ha^{-1}) as compared to absolute control but was found on par with application of 100 and 75 per cent recommended dose of fertilizers through briquettes. The application of 75 per cent recommended dose of fertilizers through briquettes showed the highest B:C ratio (2.56) followed by application of 100 per cent RDF through briquettes.

2.2.3. Production package for organic finger millet under irrigated condition

To study the efficacy of different sources of organic manures on N equivalent basis (FYM, vermicompost, poultry manure) for developing production package for oraganic finger millet under rainfed condition, a trial was conducted at Kolhapur and data collected on growth, yield and economics during kharif 2017 are presented in Table 2.2.3. Significantly higher grain (1993 kg/ha) and straw yield (3045 kg/ha) were observed in SAU's recommended package of practices as compared to absolute control and treatments which have single source for supplying nitrogen. However, it was found on par with treatments-application of 100 percent through poultry manure and 50 percent through FYM and 50 percent through Poultry manure.

2.2.5. Organic farming research in small millets – A comparative study

Experiments on organic farming in small millets were conducted at different centers. Study on Finger millet was conducted at Kolhapur (Rainfed situation) and Mandya (irrigated situation). Whereas, trials on foxtail millet were initiated at Nandyal and at Athiyandal center, proso millet and barnyard millet trials were laid out. The results of these studies are presented from table 2.2.5.

In common, the highest grain yield was observed at treatment which has an integration of organic and inorganic *i.e.,* INM (RDF+NPK) followed by the application of inorganic (RDF NPK only). Whereas, the lowest grain yield was obtained at only organics (FYM 5.0 t/ha + Vermicompost 1 t/ha + Neem cake 500 kg/ha). All crops *i.e.,* finger millet (rainfed and irrigated), foxtail millet, proso millet and barnyard millet resulted in same trend at all centers. The higher levels of available nutrients N, P_20_5 and K_2O and higher nutrient uptakes were observed at INM treatment and lower values with only organics. The soil parameters were not affected by treatment effects. B:C ratio was found high at only inorganic treatment for Finger millet (rainfed and irrigated) and Foxtail millet and for proso and barnyard millet, INM was found better (Table 2.2.5).

2.3. Assessing the performance of small millets to different sowing windows

2.3.1. Effect of different sowing windows for mitigating the climate change (Dindori)

To find out the effect of sowing windows for mitigating the climate change, an experiment was studied in Kodo millet, Little millet and Barnyard millet at Dindori during 2017. The data on growth and yield of the experiment are presented in Table 2.3.1.

There is a significant variation within grain yield among treatments. The treatment which has Normal sowing and Kodo millet showed significantly higher grain yield and documented 8 and 103 per cent higher grain yield over kodo millet sown under early and delayed sowing, respectively. Whereas, low grain yield was obtained for all crops *i.e.,* Kodo millet, little millet and barnyard millet on delayed sowings. The treatment: Normal sowing and little millet gave highest grain yield which was significantly superior (9 and 93% greater over early and delayed sowings, respectively). Besides, the grain yield of barnyard millet on normal sowing also found significant and further established 5 and 128 per cent higher grain yield over early and delayed sown barnyard millet, respectively thus proving normal sowing is suitable for all crops followed by early sowing. The similar observations are noticed for straw yield, net returns and B:C ratios.

2.3.1. Effect of different sowing windows for mitigating the climate change (Bengaluru and Nandyal)

The experiment was conducted for Foxtail millet, Little millet and Proso millet at Bengaluru and Nandyal for finding the effect of different sowing windows for mitigating the climate change. The results are presented in table 2.3.1.

At both centers Bengaluru and Nandyal, grain, straw yield and B:C ratios for all three crops at early and normal sowings found significantly higher than crops sown under delayed sowings. However, the result obtained at early sowings found on par with crops sown under normal sowing.

2.3.2. Addressing the problem of climate change (Response farming)

To evaluate different agronomic management practices to tackle droughts during the crop calendar, an experiment was initiated at two centers -Bengaluru and Athiyandal. The results of the study are presented in Table 2.3.2. During the cropping season 2017, mean over both locations indicated that the higher grain yield was obtained at treatment (Package of Practice, Control) which shows significantly superior over early, mid and late season drought. At Bengaluru, no droughts were observed during cropping season, hence the crop raised as per package of practice and hence noticed higher grain yield at package of practice (2317 kg/ha) over other situations. The same result is found even at Athiyandal center. There was no significant difference among different agronomic practices to mitigate the stress however higher value of grain yield was seen at the mitigation practices followed at early season drought. The similar observation was also seen for straw yield and B:C ratio.

2.3.3. Effect of sowing dates and finger millet varieties for delayed sowing conditions

To find out the right time of sowing and suitable varieties of finger millet to fit into contingency planning, an experiment was initiated at Kolhapur during 2017. The data on growth and yield of the experiment are presented in Table 2.3.3. Among different sowing dates tested for different varieties, sowing date on 4th week of June showed significantly higher grain yield (2014 kg/ha) than sowing date on 2nd week of June and 4th week of July but however was found on par with sowing date on 2nd week of July. Whereas, the lowest grain yield (1263 kg/ha) was found at sowing date on 4th week of July. Straw yield, number of tillers/plant, length of tillers, net returns and B:C ratios also followed the same trend. Variety Phule Nachani gave significantly higher grain yield which is found 11, 30 and 57 per cent higher than varieties GPU 28, GPU 67 and Dapoli 1, respectively. The similar trend of varieties was observed for number of tillers/ plant, length of finger, net return and B:C ratio. The interactions of sowing dates and varieties did not show any significant difference.

2.4. Weed management for small millets

2.4.1. Chemical weed control studies in finger millet (Irrigated)

The data on yield and economics are presented in table 2.4.1. Even under irrigated conditions, the highest grain yield and straw yield were achieved at two Intercultivation + 1 HW which is found significantly higher than other all treatments but found on par with Pre emergence application of Oxyflurofen @ 0.10 lit a.i / ha along with one intercultivation and Pre emergence application of Bensulfuron methyl + Pretilachlor @ 0.198 kg a.i / ha with one intercultivation and treatments which have pre emergence application of above weedicides without intercultivation. The highest B:C ratio was found at T10 (Pre emergence application of Oxyflurofen @ 0.10 lit a.i / ha along with one intercultivation) however was found on par with standard cultural practice (2 IC+HW). The next best one was pre emergence application of Bensulfuron methyl + Pretilachlor @ 0.198 kg a.i / ha with one intercultivation. Similar results were replicated at both centers Mandya and Vizianagaram.

2.4.1. Chemical weed control studies in finger millet (Rainfed)

To find out the effectiveness of pre-emergent herbicides either alone or combined with one Intercultivation were compared with standard cultural practice of two Intercultivations and one hand weeding, an experiment was initiated during 2017 at Bengaluru, Athiyandal, Kolhapur and Kanke, The data on yield and B: C ratio was presented in Table 2.4.1.

The results indicated that two inter cultivation along with one hand weeding (T11) significantly increased grain yield (116%), straw yield (115%) and B: C ratio (90%) than absolute control. The next best treatments were Pre

emergence application of Isoproturon @ 0.5 kg a.i. / ha along with one intercultivation and Pre emergence application of Bensulfuron methyl + Pretilachlor @ 0.198 kg a.i / ha along with one intercultivation. Yet the results were found same at Kolhapur and Kanke. Slight difference in grain yield at Bangalore and Athiyanda, where the significant higher grain yield at T11 found on par only with pre emergence application of Isoproturon @ 0.5 kg a.i. / ha along with one intercultivation (T10). The treatments also had similar effect on straw yield. Whereas, the B:C ratio was found significantly higher at T10 as compared to all treatments but was found on par with T11. Similar observation was noticed at all centers.

2.4.2. Weed management studies in Finger millet under irrigated condition

Under irrigated condition, a field experiment was laid out to know the efficacy of pre-emergent and post emergent herbicides with one Intercultivation on growth and yield of finger millet at Mandya during 2017. The data on yield and B:C ratio are presented in Table 2.4.2.

The grain yield, straw yield and B:C ratios differed significantly among different weed management practices. Significantly higher grain yield (4234 kg/ha) and straw yield (6496 kg/ha) and B:C ratio (2.46) were recorded with two intercultivation with hand weeding at 20 and 40 DAP, however this was found on par with pre emergent weedicide Butachlor 50 EC 750 g a.i./ha (within 3 DAP) with one intercultivation at 25- 30 DAP and post emergent weedicide Ethoxysulfuron15 WG 15g a.i /ha (15-20 DAP) with one intercultivation 35- 40 DAP.

2.4.4. Effect of different methods of crop establishment and weed control measures on growth and yield of Barnyard millet

For enhancing the productivity and profitability of barnyard millet by adopting different crop and weed management practices, a study was conducted at Ranichauri (Table 2.4.4). The results indicated that among different crop establishment methods, using high seed rate 15-18 kg/ha gave higher grain yield which was found to be the highest and found significantly superior over all methods of establishment (13, 40 and 88% higher than M4, M2 and M3, respectively). All parameters recorded *i.e.,* straw yield, gross returns, net returns and B:C ratios also followed the same trend. Whereas in weed management practices, one intercultivation with one hand weeding gave significantly higher grain yield (1927 kg/ha), straw yield (4976 ka/ha) and B: C ratio (2.14) than other weed management practices.

Details of the treatment as follows:

Main Plot treatments: Method of establishment (M): 4

- M_1: Using high seed rate 15-18 kg/ha.
- M_2: Providing wider row 45cm and plant to plant spacing 7.5 cm for Barnyard millet introduce Sun hemp in between Barnyard millet (22.5 cm) rows and harvest Sun hemp at 35-40 DAS and use as mulch.
- M_3: Delayed sowing 8-10 days after normal time of sowing (though land is ready for sowing skip sowing during the 1st spell of sowing rains – harrow the field to uproot the weeds and then go for sowing).
- M_4: Recommended/Conventional practice as per package of practice

Subplot treatments: Weed management practices (W): 4

W_1: Control (No weeding/herbicide spray)
W_2: 1 Inter cultivation (IC) + 1 HW.
W_3: Use of pre emergent herbicide (Isoproturon @ 0.5 kg a.i. /ha).
W_4: Integrated weed control (1 Herbicide spray + 1 IC).

2.6. Millet based cropping systems for sustainable productivity

2.6.2. Inter cropping studies in finger millet

To know the feasible intercropping systems in Finger millet, an experiment was initiated at Vizianagarum and Jabalpur during 2017. The data on grain yield, inter crop yield, finger millet grain equivalent yield for Kharif 2017 season are presented in Table 2.6.2.

Results indicated that the sole crop of finger millet gave significantly higher grain yield (2974 and 1936 kg/ha at Vizianagarum and Jabalpur, respectively). The significantly higher straw yield was also obtained at sole finger millet in Jagadalpur but at finger millet + urd (8:2) in Vizianagaram. On mean basis, maximum grain yield (2455 kg/ha) was observed at sole crop of finger millet followed by finger millet + green gram and finger millet + urd (8:2) intercropping system. Whereas, finger millet grain equivalent yield (FMGEY) indicated that the higher FMGEY was found at intercropping of finger millet with guar (4379 kg/ha) and finger millet with bhendi (4351 kg/ha) in 8:2 proportions. However, B:C ratios are found to be non significant among all treatments.

2.6.3. Intercropping studies in Finger millet+ Amaranthus

To find out the feasibility of intercropping and optimum spatial ratio of finger millet with amaranthus, an experiment was conducted at Ranichauri during 2017. The data on finger millet grain equivalent yield and economics are presented in table 2.6.3.

Higher finger millet grain equivalent yield (1972), net return (Rs.32587/ha) and B:C ratio (2.39) was recorded at mixed cropping of finger millet and Amaranthus (90:10 by weight) which was significantly higher than all treatments except Sole crop finger with RDF.

2.6.4. Inter cropping studies in Foxtail millet

At Nandyal during 2017, an experiment was initiated to find out feasible inter cropping system in foxtail millet to enhance yield and soil fertility. The data on foxtail millet equivalent yield and inter crop yield are presented in Table 2.6.4. Among intercropping systems, intercropping of Foxtail millet with red gram at 5:1 ratio gave higher foxtail millet grain equivalent yield (5267 kg/ha), intercrop yield (632 kg/ha) and B:C ratio (3.48) which was found significant among other intercropping systems. The sole crop of foxtail millet gave higher sole crop grain yield.

2.6.5. Sustainable intercrop association of Niger in Little millet

To evaluate the suitable intercrop association of Niger in little millet, a study was conducted at Kolhapur during 2017 and the data is presented in Table 2.6.5. The results showed that the sole crop of little millet recorded significantly higher grain (7230 kg/ha) and straw yield (9620 kg/ha) than other treatments. Significantly higher LMGEY (1175 kg/ha) and B:C ratio(1.41) were observed with little millet and niger intercropping in 4:1 association which was significantly superior over other intercrop associations followed by little millet + niger (4:2).

2.6.6. Inter cropping studies in Barnyard millet

An experiment was conducted at Ranichauri during 2017 to find out the feasibility of intercropping of amaranthus crop in barnyard millet and also to know the optimum spatial ratio. The results of the study are presented in table 2.6.6. The significantly higher BMGEY (2308 kg/ha) and B:C ratio (3.02) are obtained at an intercropping of Barnyard millet with niger in 4:1 row proportion as compared to other treatments. The next best treatment was found to be the mixed cropping of barnyard millet with amaranthus (90:10 by weight).

2.6.7. Identification of profitable barnyard millet based cropping sequence in organic mode under rainfed conditions

To identify the profitable barnyard millet based copping sequence in organic mode under rainfed conditions, an experiment was initiated at Ranichauri during 2017. The results of the study are presented in table 2.6.7. The results revealed that the application of 7.5 t/ha FYM has recorded significantly higher grain yield (31% higher) as compared grain yield without application of FYM. Among different cropping systems, Barnyard millet + Rice bean (90:10) followed by wheat observed significantly higher BMGEY (barnyard millet grain equivalent yield) as compared to other cropping sequences apart from Barnyard millet + Rice bean (90:10). However, the lowest BMGEY was observed at Barnyard millet + Rice bean (90:10). The same observation was also noticed with B:C ratio.