**6. SUMMARY AND CONCLUSION**

The results of the study entitled **“Evaluation of Water Productivity for Improved Soil and Water Management at the Scheme Scale using CropSyst Model”** which was carried out during *kharif* and *rabi* season of 2013-14 at Menawali presented and discussed in the preceding chapters are being summarized and concluded in this chapter below:

**6.1 Productivity**

6.1.1 In terms of biomass productivity, cotton produced higher aboveground biomass (8077 kg ha-1) than clusterbean (6089 kg ha-1) during *kharif* season, and among *rabi* season crops wheat (10128 kg ha-1) produced higher aboveground biomass than barley (9928 kg ha-1) and mustard (5844 kg ha-1 ), respectively.

6.1.2 The economic yields of crops varied considerably and between *Kharif* season crops, cotton produced higher yield (2212 kg ha-1) than clusterbean (1612 kg ha-1). Among *rabi* season crops wheat (4178 kg ha-1) produced higher yield than barley (3991 kg ha-1) and mustard (1936 kg ha-1 ), respectively.

6.1.3 The average biomass productivity of different cropping systems varied from 11933 to 18205 kg ha-1, being highest for cotton– wheat followed by cotton-barley, clusterbean–wheat, cotton–mustard and clusterbean–mustard. The economic yield of cropping sequences had range: 3548–6390 kg ha-1. The economic yields were higher for cotton- wheat (6390 kg ha-1) and cotton-barley (6203 kg ha-1) intermediate for clusterbean–wheat (5790 kg ha-1) and lower for cotton–mustard (4148 kg ha-1) and clusterbean–mustard (3548 kg ha-1).

**6.2 Economics**

6.2.1 Cost of cultivation of crops varied considerably and highest was observed in cotton (120px-Indian_Rupee_symbol40479 ha-1) over clusterbean (120px-Indian_Rupee_symbol23824 ha-1) during *kharif* season. Among *rabi* crops, wheat (120px-Indian_Rupee_symbol32042 ha-1) had highest cost of cultivation followed by barley (120px-Indian_Rupee_symbol28524 ha-1) and mustard (120px-Indian_Rupee_symbol25019 ha-1).

6.2.2 In case of monetary return, cotton recorded higher gross return (120px-Indian_Rupee_symbol130903ha-1) and net return (120px-Indian_Rupee_symbol90423 ha-1) with B:C ratio of 3.23 over clusterbean (120px-Indian_Rupee_symbol87276, 63452 ha-1) with B:C ratio of 3.66 during *kharif* season. Among *rabi* season crops, highest gross return (120px-Indian_Rupee_symbol88193 ha-1) and net return (120px-Indian_Rupee_symbol56152 ha-1) was recorded in wheat with B:C ratio of 2.75 followed by mustard (120px-Indian_Rupee_symbol67004, 41985 ha-1) and barley (120px-Indian_Rupee_symbol62417, 33893 ha-1).

6.2.3 The average cost of cultivation of different cropping systems varied from 120px-Indian_Rupee_symbol48842 to 72521 ha-1 and highest for cotton-wheat followed by cotton-barley, cotton–mustard, clusterbean–wheat and clusterbean–mustard. The gross and net return had ranged from 120px-Indian_Rupee_symbol154279 to 219096 ha-1 and 105437 to 146575 ha-1, respectively. The gross and net return were higher for cotton-wheat (120px-Indian_Rupee_symbol219096, 146575 ha-1) followed by cotton–mustard (120px-Indian_Rupee_symbol197906, 132408 ha-1).

**6.3 Water use and water productivity**

6.3.1 The total water applied to different crops ranged from 277.0 to 624.5 mm being maximum by cotton (624.5 mm) as compared to clusterbean (313.9 mm) during *kharif* season and in wheat (559.2 mm) during *rabi* season followed by barley (415.0 mm) and mustard (277.0 mm).

6.3.2 The total water used in terms of ET by different crops ranged from 211.8 to 456.1 mm. The highest water was used by cotton (456.1 mm) followed by wheat (442.5 mm), barley (335.5 mm), clusterbean (235.7 mm) and mustard (211.8 mm).

6.3.3 The average water used by different cropping systems varied from 590.8 to 1184.0 mm being highest in cotton-wheat (1184.0 mm) followed by cotton-barley (1039.5 mm) whereas, lowest in clusterbean–mustard (590.8 mm) cropping system.

6.3.4 With respect to water applied (physical, economic) clusterbean-mustard cropping system had highest WUE in respect of biological yield (20.20 kg ha-1mm) followed by clusterbean-wheat and in seed yield of clusterbean-wheat (6.63 kg ha-1mm) had highest WUE followed by clusterbean-mustard. Whereas, cotton-mustard and cotton-wheat had lowest WUE in yield. In monetary returns clusterbean-mustard cropping system produces highest WUE both in gross and net returns followed by cotton-mustard. However, cotton-barley and cotton-wheat had lowest WUE in gross returns and net returns.

6.3.5 With respect to ET, clusterbean-mustard cropping system had highest WUEET in respect of biological yield (26.67 kg ha-1 mm) and clusterbean-wheat in respect of economic yield (7.8 kg ha-1 mm) whereas cotton-mustard and cotton-wheat had lowest WUEET in yield. In monetary returns clusterbean-mustard cropping system produces highest WUEET both in gross and net returns followed by cotton-mustard. However, cotton-barley and cotton-wheat had lowest WUEET in gross returns and net returns.

**6.4 N-uptake**

6.4.1 The average N-uptake of different crops varied from 61.1 to 105.9 kg ha-1 in which cotton recorded higher N-uptake (77.0 kg ha-1) than clusterbean (69.8 kg ha-1). In kharif season The observed increase in N-uptake of cotton was 10.7 per cent over clusterbean in *kharif* season. Among the *rabi* season crops barley recorded higher N-uptake (98.0 kg ha-1) than other crops with the increase to the tune of 1.9 and 31.0 % higher N-uptake than wheat and mustard, respectively.

**6.5 Model validation**

6.5.1 The maximum GAI of 2.4 m2m-2 was observed at 90 DAS which was moderately smaller than validated value of (2.5 m2m-2). Observed and validated GAI matched well with a RMSE of 0.20 cm2cm-2. Correlation coefficient of 0.98 and Index of agreement of 0.98 was achieved for GAI of cotton.

6.5.2 The validated yield (2275 kg ha-1) of cotton was closer to the observed seed cotton yield of 2212 kg ha-1 with 3.81% RRMSE. The correlation coefficient of 0.86 and Index of agreement of 0.84 was calculated for yield of cotton.

6.5.3 The validated aboveground biomass (8750 kg ha-1) was higher than observed aboveground biomass (8077 kg ha-1) with 8.67% RRMSE. Correlation coefficient of 0.88 and Index of agreement of 0.51 calculated for aboveground biomass of cotton.

6.5.4 The validated N-uptake (86.0 kg ha-1) was higher than observed N-uptake (77.0 kg ha-1) with 14.6% RRMSE. Correlation coefficient of 0.87 and Index of agreement of 0.45 was calculated for N-uptake of cotton.

6.5.6 The RMSE of moisture content in cotton field ranged from 0.0205 to 0.0260. Validated value of moisture content predict well with observed values in the upper layers. The index of agreement was 0.90 in top soil layers of 0-10 cm.

6.5.7 The maximum GAI (2.6) of clusterbean was observed at 40 DAS which was lower than validated value (3.2). The observed and validated GAI matched well with a RMSE of 0.58 cm2cm-2. Correlation coefficient of 0.87 and Index of agreement of 0.93 observed for GAI of clusterbean.

6.5.8 Validated yield (1558 kg ha-1) of clusterbean were closer to the observed yield of (1612 kg ha-1) with 5.93% RRMSE. Correlation coefficient of 0.74 and Index of agreement of 0.81was calculated for yield of clusterbean.

6.5.9 The validated aboveground biomass (5927 kg ha-1) was lower than observed aboveground biomass (6089 kg ha-1) with 6.38% RRMSE. Correlation coefficient of 0.73 and Index of agreement of 0.81 was calculated for aboveground biomassof clusterbean.

6.5.10 Validated N-uptake 75.0 kg ha-1) was higher than observed N-uptake (70.0 kg ha-1) with 8.9% RMSE. Correlation coefficient of 0.75 and Index of agreement of 0.60 was calculated for N-uptake of clusterbean.

6.5.11 Among the various parameters, CropSyst predict aboveground biomassand and economic yield of clusterbean better than GAI and N-uptake.

6.5.12 The RMSE of moisture content in clusterbean field ranged from 0.0204 to 0.0298. Validated value of moisture content predict well with observed values in the upper layers. The index of agreement was 0.90 in bottom soil layers of 60-90 cm.

6.5.13 The Maximum GAI of wheat (3.6) was observed at 90 DAS which was moderately lower than validated value (4.0).

6.5.14 Validated yield (4090 kg ha-1) of wheat were closer to the observed yield of 4178 with 3.7% RRMSE, correlation coefficient of 0.74 and Index of agreement of 0.81 for yield of wheat.

6.5.15 Validated aboveground biomass (10260 kg ha-1) was higher than observed aboveground biomass (10128 kg ha-1) with 5.3% RRMSE, correlation coefficient of 0.83 and Index of agreement of 0.90 for AGB of wheat.

6.5.16 The validated N-uptake (88.3 kg ha-1) was lower than observed N-uptake (96.1 kg ha-1) with 14% RMSE, correlation coefficient of 0.82 and Index of agreement of 0.54 for N-uptake of wheat.

6.5.17 Among the various parameters, CropSyst predict economic yield, aboveground biomass and N-uptake better than GAI of wheat.

6.5.18 The RMSE of moisture content in wheat field ranged from 0.0211 to 0.0243. Validated value of moisture content predict well with observed values in the upper layers. The index of agreement was 0.90 in top soil layers.

6.5.19 Maximum GAI of 2.4 of mustard was observed at 60 DAS which was slightly lower than validated value (2.7).

6.5.20 Validated yield (1866 kg ha-1) of mustard were closer to the observed yield of (1778 kg ha-1) with 6.36 % RRMSE, correlation coefficient of 0.83 and Index of agreement of 0.85 for yield of mustard.

6.5.21 Observed aboveground biomass (5915 kg ha-1) was higher than validated aboveground biomass (5764 kg ha-1) with 4.68% RRMSE, correlation coefficient of 0.87 and Index of agreement of 0.89 for aboveground biomass of mustard.

6.5.22 Validated N-uptake (82.2 kg ha-1) was higher than observed N-uptake (74.8 kg ha-1) with 19.1% RMSE. The Correlation coefficient of 0.90 and Index of agreement of 0.59 observed for N-uptake of mustard.

6.5.23 Among various parameters, economic yield was predicted well by CropSyst than N-uptake and GAI.

6.5.22 The RMSE of moisture content ranged from 0.0208 to 0.0257. validated value of moisture content predict well with observed values in upper layers and the index of agreement was 0.90, in top soil layer of 0-10 cm.

6.5.25 The maximum GAI of 3.9 was observed at 90 DAS which was slightly lower than validated value (4.6) with 0.38 RRMSE. The correlation coefficient and index of agreement were 0.98 and 0.99, respectively.

6.5.26 Validated yield (4128 kg ha-1) of barley were closer to the observed yield of (3991 kg ha-1). The correlation coefficient and index of agreement were 0.85 and 0.72, respectively.

6.5.27 Observed aboveground biomass (10129 kg ha-1) was higher than validated aboveground biomass (9927 kg ha-1). Correlation coefficient of 0.78 and Index of agreement of 0.58 observed for AGB of barley.

6.5.28 Validated N-uptake (94 kg ha-1) was lower than observed N-uptake (98 kg ha-1). Correlation coefficient of 0.86 and Index of agreement of 0.76 observed for N-uptake of barley.

6.5.29 The RMSE of moisture content ranged from 0.0138 to 0.0230 in barley field. Validated value of moisture content predict well with observed values in the upper layers up to 60 cm. The index of agreement was 0.96 in top soil layer of 0-10 cm.

**CONCLUSION**

The present study shows that by using the careful parameterization for CropSyst model, the practical value of this model may hold good in simulating cotton, Clusterbean, wheat, mustard and barley crops when used for management and legislative purpose. The CropSyst model simulates and validates the biomass and grain yield reasonably well for cotton, Clusterbean, wheat, mustard and barley. The model underestimated the biomass and grain yield of Clusterbean, mustard and grain yield of wheat while overestimated cotton, barley and biomass yield of wheat. The model is sensitive to parameters like light to above ground biomass conversion and phonological degree days and is not sensitive to parameters like maximum harvest index and cut off temperature. The results suggested that cotton based cropping system were more profitable and Clusterbean based cropping system were more water productive than other cropping system. It is therefore desirable that such crop rotation should be selected which may result into maximum conversion of inputs into economic outputs and simulation and validation using CropSyst model should be adopted to help planners in achieving these goals with least monetary requirements at proper time. Further the fine tuning of CropSyst model with more experimentation is required.