III.3.4 Tactical Decision Making Based on Weather Information

III.3.4.(I) Problems and Solutions in Using of and Coping with Weather Phenomena in Need of Tactical Decision Making and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Viable Solutions in This Context: Multiple Cropping

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Walker et al. (2011) recently summarized for seasonal tactical aspects that there are many sorts of combination used in intercropping layouts or design in the field. There are also a variety of different ways of looking systematically at intercropping systems – either by height or climate zone or reason or purpose for which the crops are grown etc. If one considers that the intercrops are limited to those that are grown in the same field or land at the same time, albeit part of the growing season, then there can still be many different combinations. The crops can be either annuals or perennials (in the latter case the choice is strategical) and they can be of similar or different growth cycles and growth habits.

Then the arrangement in the field also has a range of possibilities: completely randomly mixed if seed is broadcast, or in mixed crop rows, or mixed crops in the same rows or in alternate rows of each crop, or alternate groups of rows of each crop or tree or as alternating strips of each crop, or the trees are in belts, hedges or other boundary plantings, or trees are randomly spaced in nature and the crop is grown under them (e.g. Baldy and Stigter 1997 and examples also in the literature of Sect. III.3.4.(II).

Then when compared to the sole crop there can also be a variety of densities – they can be as a pair-wise intercropping series or additive intercropping series or replacement intercropping series or a responsive intercropping series design (Connolly et al. 2001). So when one is talking about tactical decision making related to weather phenomena in intercropping, one should take care to carefully describe

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the plant arrangements and planting timing systems before one tries to analyze the results and especially before one tries to extrapolate the results into a different situation (Walker et al. 2011).

One of the greater tactical effects that intercropping can have in using or coping with weather phenomena is that on the soil water use and management through the growing season. To obtain an understanding of the water strategies of the intercrops, one has to investigate and understand the distribution of the roots in the soil profile (e.g. Umaya et al. 1999; Mungai et al. 2001; Oluwasemire et al. 2002; Oteng'i et al. 2007; Walker et al. 2011). See also Box III.3.1 in Sect. III.3.1.(a).

This will then help to explain the water (and nutrient) extraction patterns and water (and nutrient) use by the combined crops in the intercropping system. Mungai et al. (2001) for example explained differences in behaviour of a bean/maize intercrop under trees from a season in which incidentally another maize variety had been planted that had colonized the soil layers differently as to nutrient extraction. This was recognized in the maize growth of the following season.

In another example, the cowpea rooting system in the intercrop was well developed and more extensive even than other legumes (e.g. Oluwasemire et al. 2002; Rusinamhodzi et al. 2006). These more extensive rooting systems can then explore the soil to greater depths and volumes and so provide a means of promoting better utilization of natural resources.

This was also the case when the soil water balance was measured to a depth of 1,200 mm and a maize/bean intercrop was able to extract more water than either of the sole crops of maize or beans (Walker and Ogindo 2003). The intercrop's transpiration through the season was higher than that of either sole crop and this was attributed to the more prolific root system of the combined crops so that they were able to explore the soil profile more fully (e.g. Ogindo and Walker 2005). Rainfall distribution patterns do influence such effects of course as well, and trying to use the weather phenomena this way is just playing the higher efficiency potential cards.

Intercrops have generally been shown to give substantial improvement in water use efficiency (e.g. Morris and Garrity 1993). Oluwasemire et al. (2002) found millet using water more efficiently for grain production in its intercrops in a drier year. It showed better adaptation to moisture stress by producing similar harvest indices in sole and intercropped millet. The components used in calculating water use efficiency are the yield and the water use. The yield under intercropping needs to include that from both contributing crops and so probably is best expressed in terms of the energy value (Walker et al. 2011).

The components of the water use can be divided into the sum of the transpiration and the evaporation directly from the soil surface. However, these components are rarely separated in agronomic studies (e.g. Kinama et al. 2005). But if one is to evaluate the true productivity of the water used by the crops, one should only use the transpiration or green water as this is what is converted into biomass and yield (Walker and Ogindo 2003).

The method often used to separate the two components is that of the transpiration coefficient (e.g. Ogindo and Walker 2004). In semi-arid areas, the highest soil evaporation has been reported to be between 50 and 65% under sole crop (Ibrahim et al. 2002) or sole crop like (Kinama et al. 2005) conditions, although Walker et al. (2011) report even higher values from the literature under farmers' field conditions. Under these high evaporative demand situations, the useful water for transpiration and thus conversion to biomass is extremely low.

However, if intercropping was to be practised, there would be a higher coverage of the soil by the second crop and so it forms a sort of green or living mulch (e.g. Stigter and Baldy 1993). While it will use water for transpiration, this will also produce a crop and thus be useful water and at the same time decrease the bare soil surface evaporation. This would then also increase the water use efficiency of the combined crop (Walker and Ogindo 2003).

Together with the root system, the above soil biomass distribution is in this and other ways another tactical use made of the space in which the weather phenomena and their consequences are met and used as efficiently as possible. Because operational agrometeorology wants to solve local problems of farmers, the challenges remaining are testing new farming systems on-farm in the above suggested directions (e.g. Stigter et al. 2007). More details are also at the end of the subsequent Sect. III.3.4.(II).

In the context of adaptation and climate change resilience, we may conclude that intensification of agriculture, promoting local capacity for improved crop production, improvement in traditional farming systems and use of climate information will be the main means to increase production (Fischer et al. 2002; Stigter et al. 2005; Winarto et al. 2008). From the sections in this chapter it has become clear what multiple cropping can do here if supported by applied science. In many developing countries, provided adequate inputs and improved management strategies are applied, there is this way considerable scope for increased yields (Baldy and Stigter 1997; Fischer et al. 2002).

Adaptation strategies generally adopted and dealt with throughout Chap. III.2 that still have to be developed much wider for multiple cropping, include: adjustments to planting dates; changes in fertilization; irrigation applications; applying cultivar traits; using crop residues and cover crops; recourse to indigenous knowledge; better use of local natural resources and processes; mixed farming with adapted selection of animal species; a different utilization of marginal lands (such as for fuel crops instead of food crops); agroforestry; local specialized early warning systems; and livelihood diversification. Examples are found throughout this Chap. III.3. Research needs we therefore want to recognize in agrometeorology of multiple cropping are:

i. crops of contrasting growth habits should be selected: e.g. canopy types, crop morphology and root systems;

ii. identifying the best mixture of the crop species e.g. effect of planting densities on main and companion crops, planting densities on fertilizer use, composition on pests and diseases (Box III.3.15);

Box III.3.15

Reijntjes et al. (1992) have already long ago exemplified the generally positive effects of intercropping in terms of reducing the occurrence of insect pests, diseases and weeds as follows. Standing rice stubble can camouflage bean seedlings and protect them from bean fly. Many issues have microclimatological components related to weather and climate phenomena. Intercropping can for example interfere with the population development and survival of insect pests, because companion crops block their dispersal across the field and it may be more difficult for them to locate and remain in microhabitats which favour their development. In tactical decision making, such mechanisms can be used to change and improve existing intercropping systems as to reduce insect populations. With few exceptions, intercrops suffer less diseases than pure crops with the same overall density. Provided the pathogen/host/environment relationship is understood, like that is also aimed at in monocropping, the use of intercropping shows great possibilities for reducing disease. In many intercropping systems, only one weeding is required compared to 2–3 in sole crops, due to the shading and smothering provided. This weeding is often combined with planting another intercrop, thus reducing the time spent solely on weeding. These are again tactics using opportunities offered by environmental management.

iii. performance of improved crop varieties e.g. for drought resistance under multiple cropping systems;
iv. labor requirements (and functions) and machinery requirements (and functions) under multiple cropping systems – Farm practices that will accelerate harvesting of the first crop and the planting of the second crop;
v. develop early maturing crops;
vi. moisture conservation methods suitable for multiple cropping;
vii. identify nutrient needs under multiple cropping;
viii. productivity of companion crops under different cropping intensity and shading levels;
ix. crop rotations and fertility – Improved crop sequences involving rotation of soil exhausting crops followed by recuperative ones, shallow rooted crops followed by deep-rooted ones, legumes in rotation with non-legumes.

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