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RESEARCH ARTICLE

AGRICULTURAL INTENSIFICATION: A VIABLE OPTION FOR FOOD AVAILABILITY AND SUSTAINABILITY

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ABSTRACT

The land available for agriculture to feed the population that is growing geometrically, has reduced drastically due to urbanization. This has led to the use of arable land for industrial purposes. Industrialization has reduced the arable land available for agriculture to feed the ever growing population. To remedy this situation and ensure that the people don't starve, there is the need to intensify agriculture by adopting a cropping system that utilizes the available resources on the land by increasing input on that available land to bring about increase output. Intercropping is one of the methods of intensifying agriculture. It involves the growing of two or more crops on a particular piece of land for efficient use of the resources available in that land for increase productivity. for a successful intercropping enterprise, there is the need to have knowledge of crop management techniques like spacing, spatial arrangement, planting density, varietal selection, understanding the physiology of the plants to be grown together, their growth habits, canopy and root architecture, water and nutrient use in order to manage interaction that occurs in favour of the component crops. This review tends to study the role of plant spacing, spatial arrangement, plant density, plant architecture in agricultural intensification for food sustainability and availability.

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INTRODUCTION

The need for intensification in agriculture became necessary as human population increases geometrically without commensurate advancement in technology to ameliorate the possible effect. Urbanisation and industrialization has drastically reduced arable land available for agricultural purposes. To curb this trend, multiple cropping system which effectively utilizes the available arable land becomes paramount (Uwumarongie *et al*., 2022) . Sole/monocropping or plantation agriculture requires vast areas of land for cultivation, hence the need for intensive agriculture which is predicated on average increase in input such as labour and/or capital in cultivated land and/or grazing land to bring about increase output (FMARD, 2001). Prey *et al* (2011) noted that the major factors that drive Agricultural intensification are shortened fallow periods, soil fertility, declining per capita agricultural land size/access to farmland, population pressure on a fixed land resource, and rapidly changing consumption patterns. Other factors are impacts of climate change and environmental degradation, inadequate agricultural technology, over-cultivation and low use of agricultural inputs.

INTERCROPPING AS A WAY TO INTENSIFY LAND-USE SYSTEM

Intercropping is the growing of two or more crops simultaneously on the same piece of land with a definite row pattern in order to increase total productivity per unit land area and make judicious use of available resources such as land, labour etc. Intercropping helps to intensify land use system by incorporating crops of different growing periods and habits, thereby making their demand for major growth resources at different times (Ofori and Stern, 1987). This system also takes advantage of the N-fixing ability of leguminous crops to intensify land use system by incorporating leguminous crop with non-leguminous crop. The symbiotic relationship with the N-fixing bacteria in their root nodules helps to replenish the N depletion in the soil thereby making it available for the component crops Legume helps to sustain organic matter content in the soil which enhances biological activities, improves soil fertility and increases nutrient availability. Legumes like cowpea (*Vigna unguiculata*), is an important crop in Nigeria because of its high protein content and its ability to fix atmospheric nitrogen with high efficiency. It also promotes the growth of the component crops in intercrop by improving poor soils (Futuless and Bake, 2010).Intercropping systems that incorporate leguminous crop can provide symbiotically-fixed nitrogen and potentially increases yield through improved land resource use efficiency (Pappa *et. al*., 2011). Since the land available for farming is reduced due to population explosion, farmers are encouraged to make judicious use of the available land for optimum production by intercropping plant with dissimilar growing patterns, morphology, phenology and nutrient requirements. Legumes, with their adaptability to different cropping patterns and ability to fix atmospheric N offer minimum competition for N nutrition and greater opportunities to sustain productivity (Sanginga *et al.*, 2002).

The most important goal of agricultural intensification is to maximize production and profit while minimizing risks of possible crop failure and negative interaction to the barest minimum by ensuring that the limited resources is judiciously utilized. To be able to utilize these limited resources, the farmer must ensure these various factors that influence intercropping are positively put in place, these factors include:

TIME OF PLANTING/PLANTING DATE

In intercropping systems, sowing/planting time of component crops may or may not vary as in relay intercropping system(). Intercrops are introduced when the base crop reaches close to its maturity or complete a major period of its growth. The competition among the species is much less in relay intercropping. It is important to vary the planting date of crops in intercrop to prevent inter specific competition for available plant resources between component crops. Planting date helps to regulate the component crops, in such a way that one of the crop in intercrop matures before the other gets to its active growth stage when nutrient is in high demand. Manipulating planting date can also help to make harvesting easy as there can be staggered harvesting

EFFECTS OF PLANTING DATE ON CROPS IN INTERCROP

Saddam *et al*., 2012 reported that early planting significantly increased the fruit and gave a higher number of branches per plant, number of umbrella per plant, number of fruit per plant and plant height. in another development Paolo, 2012 in an experiment to study the effect of sowing/planting date on maize productivity observed that delay of sowing date of between 15-20 days significantly reduced grain yield, in the same vein, researches in bean production has proven that Early planting of common bean can enable the crop to set and fill grain before the onset of late-fall chilling and that Early planting can also provide the potential for producing a larger crop canopy earlier in the growing season, which can better utilize solar radiation for photosynthesis (De Bruin *et al*.,2010). it can also increase crop competitiveness against weeds, especially against late-emerging ones. although very early planting of common bean exposes the germinating seeds to dry and warm conditions and, therefore, it has the potential to reduce stands and to cause uneven seedling emergence. Combining uneven seedling emergence and lower populations under these conditions may cause greater yield reductions. late planting date on the other hand causes the reproductive growth stage of the crop to face the fall chilling, which ultimately lowers yield due to the sensitivity of common bean to low temperature (Badowiec & Weidner, 2014)

PLANT SPACING

Plant spacing refers to the arrangement of plants on the area planted. Proper plant spacing helps us to avoid a tangled mess of branches in a given field, by giving plants enough room to grow into maturity, and ensure they remain visually pleasing to the eye all through the stay on the field. Aside aesthetics importance of plant spacing, it also helps to reduce overcrowding which might possibly lead to competition for available nutrient in the soil and disrupt light penetration to the plant. Hence it is critical to ensuring long-term plant health. When plants are crowded together, they compete for water, nutrients, and sunlight. Crowded plants often bloom poorly due to poor nutrition, or because not enough light reaches the shaded branches. In a vegetable garden, this results in lower yields. By spacing plants to accommodate the expected mature size of a plant, you ensure plants have enough room to develop a healthy root system and limit competition for access to water and nutrients. As a result, plants are less stressed and Proper plant spacing also allows for adequate air circulation around plants, which helps fight plant diseases. Many disease agents require a moist or humid environment to develop. In crowded plantings, reduced airflow prevents moisture from evaporating from leaf surfaces, increasing the likelihood of foliar diseases. Good air circulation through proper plant spacing helps reduce fungal diseases in the field and resistant to pest problems.(Toscano, 2022)

EFFECTS OF PLANT SPACING ON COMPONENT CROP IN INTERCROPPING

Several experiments have been conducted to look at the effect of plant spacing on the growth and yield of different crops. Saddam *et al.,*(2012)studied the effect of plant spacing on growth and yield of Fennel (*Foeniculum vulgare* Mill.).Four spacing parameters were tested: 10,20,30 and 40 cm and constant row width of 60cm.They discovered that fruit yield was significantly influenced by spacing and concluded that spacing of 30cm gave the highest fruit and biological yield in Fennel. Gwiranenzara *et al.* (2014) reported that a spacing of 0.7 m × 0.2 m gave higher seed cotton yield compared with wider spacing of 1m × 0.3m. This outcome drew a suggestion of better photosynthetic potential due to better light interception. In another experiment conducted to test the effect of different cotton spacing on yields and components of seed cotton, it was discovered that there was a general trend that densely populated cotton has more yield than sparsely populated ones. In general, highly populated plants have a tendency of closing the ground faster than sparsely populated plants and thus optimum leaf area index is normally reached faster in the densely populated crops as compared with sparsely populated crops. As the plant develops, assimilates supply increases asymptomatically as leaf areas increases (Xie *et al*. 2018).

PLANT DENSITY/ POPULATION

Plant density in intercropping is a critical factor that should be considered before embarking on intercrop to avoid overcrowding which may lead to low yield as a result of depletion of soil nutrient. To optimize plant density, the seeding rate of each crop in the mixture is adjusted below its full rate. If full rates of each crop were planted, neither would yield well because of intense overcrowding. By reducing the seeding rates of each, the crops have a chance to yield well within the mixture. The challenge comes in knowing how much to reduce the seeding rates. For example, if you were planning to grow corn and cowpeas and you want mostly peas and only a little corn, it would be easy to achieve this. The corn-seeding rate would be drastically cut down (by 80% or more) and the pea rate would be near normal. The field should produce near top yields of peas even from the lower planting rate and offer the advantage of corn plants for the pea vines to run on. If you wanted equal yields from both peas and corn, then the seeding rates would be adjusted to produce those equal yields. Adjusting/reducing the seeding rate of crops planted in intercrop is essential to give room for high productivity. If the crops in intercrops are sown in the same rate as sole, the production will be less; hence, plant population helps to look at the crops in intercrop and note the one which in most needed or marketable or in high demand and sow it almost at the normal seeding rate while others are sown at 50 to 60 %thereby giving optimal yield of the main crop and complimentary yield of the component crop.

EFFECTS OF PLANT DENSITY/POPULATION ON COMPONENT CROPS IN

INTERCROP

Plant population density alters leaf azimuthal distribution. It also influences plant sizes. Appropriate plant density is an important crop management practice that can optimize canopy light distribution and increases canopy photosynthetic capacity. It was found that there was a general trend that densely populated crops have more yield than sparsely populated plants. In general, highly populated plants has a tendency of closing the ground faster than sparsely populated plants and thus optimum LAI is normally reached faster when compared with sparsely populated crops. Paolo (2012) observed that the density of maize may be increased up until 10 plants m-2 for optimum production using a row spacing of 0.5 or 0.9m depending on the varieties. Short varieties accommodate narrow spacing while the tall varieties need wider spacing up to 2m. Teshome *et al*. (2015) recommended a planting population of 50% soybean for optimum productivity in a soybean-maize intercrop. Cotton has been proven by research to do well with adequate light penetration (Chapepa *et al*., 2020). Researches in cotton production has shown that leaf azimuthal distribution is altered by plant population density, it also influences plant sizes. Appropriate plant density is an important crop management practice that can optimise canopy light distribution and increase canopy photosynthetic capacity in cotton (Yao *et al*. 2016).

CROP VARIETY/CULTIVAR

The crop choice is an important consideration in intercropping system Crop marketability, suitability as well as demand and availability of a particular variety are important factors in intercropping system. The appropriate crop mixtures show complementarity among the species cultivated and yield advantage. Crop variety is a very important factor to consider in intercropping system as the essence of growing crops is to be able to market the product and make profit; hence, we must answer the question is the crop marketable? The state of the environment (soil and weather condition), the suitability of the crop to the environment is to be considered because crop varieties respond to soil and weather condition differently for optimal yield.

EFFECTS OF VARIETY/CULTIVAR ON COMPONENT CROPS IN INTERCROP

Teshome, *et al*., (2015) in an experiment to look at the effect of varieties and population of intercropped soybean with maize on yield and yield components observed that number of pods per plant was significantly affected by variety. They recommended Didesa soybean variety for intercrop with maize for optimal result. The best cultivar for monocropping might not be most suitable for mixed cropping due to changes in microclimate within crop mixture (O'Leary and Smith, 2004). Refay *et. al*.,(2013), studies conducted to evaluate variety, cropping pattern and plant density on growth and yield of sorghum-cowpea under limited water supply condition. Growth, yield and yield components of sorghum, two semi dwarf and one tall variety of sorghum were tested. The results of the experiment showed that growth parameters, yield and yield components were significantly affected by the variety: the semi-dwarf variety surpassed the tall variety and this superiority of the semi-dwarf varieties was expected because the recommended plant density of the semi-dwarf varieties is higher as compared to the tall variety.

CONCLUSION

To be able to meet up with the food demand of the ever increasing population using the limited arable land, all effort must be put in place to intensify agriculture using intercropping as a viable option. A successful intercropping is predicated on a proper understanding of the effects of plant spacing, spatial arrangement, planting density, varietal selection, understanding the physiology of the species to be grown together, their growth habits, canopy and root architecture, water and nutrient use efficiency and crop interaction.

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