academicJournals

Vol. 10(7), pp. 727-730, 12 February, 2015
DOI: 10.5897/AJAR2014. 8557
Article Number: B45528250403
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Review

Growth, yield and quality responses to plant spacing in Irish potato: A review

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Received 27 January, 2014; Accepted 22 January, 2015

A review of literature was conducted on how growth, yield and quality respond to plant spacing in Irish potato. A number of parameters were considered: stem length, stem number, tuber numbers, tuber size categories, total yield, marketable yield, dry matter content and specific gravity. Some contradictions were exposed showing the need for further researches concerning how spacing interacts with the environment and other production practices including varietal choices. This information will help producers to optimise productivity.

Key words: Plant spacing, potato growth, potato yield, potato quality.

INTRODUCTION

How closely potato plants are spaced in a field affects markedly the growth, yield and quality of the crop. Plant population studies in potato production were among the earliest and most common field experiments (Caliskan et al., 2009; Foti, 1999) and continue to be of immense importance. The most recent in this area include the work by Masarirambi et al. (2012) and Getachew et al. (2013). Some works have focused on optimizing crop production and profitability (Rex et al., 1987; Wurr et al., 1993). Since new cultivars are continually being released, these studies will continue to be essential (Barry et al., 1990; Wurr et al., 1993). Such new cultivars will differ in how their growth, yield and quality will be influenced by how far apart the individual plants will be spaced in a field. In any unique growing locality, the optimum plant population levels must be well established (Kabir et al., 2004; Rykbost and Maxwell, 1993). Masarirambi et al. (2012) asserted that there was still much to learn about even the simple interrelationships of haulm and tuber growth and the interferences between branches. If these inter-relationships are well understood, the crop would be managed well, so as to provide a wide range of responses. Such responses could include radiation interception, the influence of climate variation on maturity and earlier tuber formation, and the number and sizes of tubers at maturity (Masarirambi et al., 2012).

EFFECT OF PLANT SPACING ON GROWTH

Some studies, for example those by Fonseka et al. (1996), Ifenkwe and Allen (1978), in which the relation between plant spacing and growth were examined, the results showed an increase in plant spacing to be

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accompanied by an increased stem length. The increased branching at the wider spacing did not compensate for fewer plants/m^2. They attributed increased branching at wider spacing to the availability of more space at lower plant densities. More space meant that plants were able to exploit the available nutrients in the soil and the photosynthetic active radiation for growth than plants at close spacing. In other words, the growth rate was increased. Vander Zaag et al. (1990) studied the response to plant population under two different sites; one temperate and the other tropical. At the temperate site, closer spacing increased plant height. At the tropical site, closer spacing decreased plant height when canopy cover did not reach 100%.

Other studies have examined the effect of planting population on stem number. Bussan et al. (2007) showed that stem density (number of stems emerging from all planted tubers) increased linearly with increasing plant density (number of seed tubers planted per unity area), but the response differed across years. They highlighted that the linear response indicated that the stems per plant were not influenced by plant density. This was confirmed by other workers (O'Brien and Allen, 1992; Knowles et al., 1985; Love and Thompson-Johns, 1999; Rex, 1990; De la Morena et al., 1994; De la Morena et al., 1994; Khalafalla, 2001; Rex, 1991). Stems per plant were not influenced by plant density but by physiological factors resulting from the management of the seed. Masarirambi et al. (2012), however, found population density to have a highly significant influence on the subsequent development of secondary stems. Stem numbers were reduced at high plant density level and increased significantly at lower densities. This is likely due to intense competition for light, water and nutrients at high densities. Wurr et al. (1993) attributed the reduction in stem number and development at the high-density spacing levels to the limited space for root and tuber expansion.

Masarirambi et al. (2012) found out that plant population density (E) had an impact on above ground biomass production, specifically leaf area production, with plants grown at a spacing of 90 by 45 cm exhibiting highest haulm growth. The least values of leaf area production were recorded at 90 by 15 cm. Masarirambi et al. (2012) also found a lower leaf area at highest crop density (90 × 15 cm) than at 90 × 30 cm. Ifenkwe and Allen (1978) found that increasing planting density reduced number of axillary branches and their leaves per plant, dry weight of leaf, stem, underground parts and tubers per plant, but increased stem length. Almekinders (1993) showed that increasing plant density resulted in cessation of shoot growth at an earlier stage and concentrated inflorescence and flower production at primary positions of early-flowering shoots. He worked on spacing but using different cultivars. With cultivars Renacimiento and Yungay, a higher plant density increased the percentage of flowers produced in the first three weeks of the flowering period but with cultivar Atzimba, the effect of plant density on the distribution of flower production was off-set by a slower stem development.

EFFECT OF PLANT SPACING ON TUBER NUMBERS

High numbers of tubers at high plant densities have been reported by O'Brien and Allen (1992), Iritani et al. (1983), Hammes (1985), Wurr et al. (1993), Allen and Wurr (1992), Karafyllidis et al. (1996), Wiersema (1986). The high number of tubers at high densities may be accounted for by the fact that at low density plantings, fewer sinks are produced per unit area and increase as the planting density increased. This is in contrast with Masarirambi et al. (2012), Strange and Blackmore (1990), Vander Zaag et al. (1990) and Güllüoglu and Arioglu (2009) who found out that the availability of space had an effect on number of tubers formed. The greater the space, the higher the number of tubers formed (Güllüoglu and Arioglu, 2009).

EFFECT OF PLANT SPACING ON YIELD

Reduced plant population was reported to increase yield (Arsenault and Malone, 1999; Vander Zaag et al., 1990; Mauromicale et al., 2003). Work by Güllüoglu and Arioglu (2009) revealed that major yield components; mean tuber weight and tuber yield per plant, significantly decreased as planting distance got closer due to increasing inter-plant competition. Rykbost and Maxwell (1993) showed that only one out of seven varieties showed reduced total yield at low populations.

Contrastingly, reports of increased yield at high plant population are available (Güllüoglu and Arioglu, 2009; Nelson, 1967; Wurr et al., 1993; O'Brien and Allen, 1992; Rex, 1991; Strange and Blackmore, 1990; Love and Thompson-Johns, 1999; Iritani et al., 1983; De la Morena et al., 1994; Bleasdale, 1965; Allen and Wurr, 1992). Khalafalla (2001) attributed this to increased number of plants/unit area and more tubers/plant. Similar results were reported by Nelson (1967) in North Dakota. He found that increased plant populations reduced average tuber weight but increased yields due to more tubers being harvested. Similarly, Giovanni and Signorelli (2003) reported yield increases. In a study by Masarirambi et al. (2012), yield was not affected by population density although they did not examine the tuber size distribution which would have shown an increase in smaller tubers with increased plant population.

TUBER SIZE

Plant spacing has been manipulated in the production of seed sizes that can satisfy the targeted market. Farmers that produce tubers for seed tend to produce smaller tubers because that is what the market demands whereas for processing markets bigger tubers are required. A number of researches have been carried out to investigate the effect of plant spacing on tuber size category. In studies done by Getachew et al. (2013), tuber bulking of individuals at close spacing was reduced resulting in small tubers. Khalafalla (2001), Love and Thompson-Johns (1999), Nelson (1967) and Cortbaoui and Center (1988) also showed that closer spacing resulted in smaller tubers. In a similar studies but using different varieties, Rieman et al. (1953) showed that the cultivar Russet Burbank had a tendency to produce many tubers of small size implying a genetic influence on tuber size.

However, work by Güllüoglu and Arioglu (2009), Love and Thompson-Johns (1999), and Getachew et al. (2013) found that a larger proportion of large sized tubers occurred when a wider spacing was used. Getachew et al. (2013) attributed this to the presence of fewer sinks that were available per unit area. That in turn resulted in less competition between the individuals. Other researchers also supported the same findings (Yenagi et al., 2010; Essah, 2004).

MARKETABLE YIELD

In terms of the marketable yield, the results from researches carried out by a number of researchers are also contrasting. Khalafalla (2001) carried out his studies on 2 different sites namely Shehainab and Shambat. He found marketable yield to increase as the spacing was reduced except when the research was carried out again in another year. At Shambat marketable yield significantly ($P<0.05$) increased with close spacing and out-yielded wider (35 cm) spacing by 26%. Love and Thompson-Johns (1999) used different varieties and when tested on different plant spacing that were used, responded differently with regard to marketable yield. Variety Ranger Russet produced higher marketable yield at narrowest spacing than Russet Burbank whilst variety Frontier Russet was intermediate. Entz and LaCroix (1984) in their research where they studied the effect of row spacing and seed type on yield and quality found that those plants grown from large seed pieces produced higher marketable yield at the widest spacing. Lynch and Rowberry (1977) also found marketable yield to respond negatively to an increased plant density.

EFFECT ON SPECIFIC GRAVITY

Numerous studies showed that increasing plant spacing resulted in an increase in specific gravity (Vander et al., 1990; Burton, 1948; Zebarth et al., 2006). Getachew et al. (2013) attributed this to the resultant less intra-plant competition associated with reduced plant population. Fonseka et al. (1996) also observed a fall in specific gravity as the plant spacing was increased from 30 to 35 cm drawing the same conclusion as Getachew et al. (2013). White and Sanderson (1983) also showed that wider spacing (38 and 56 cm) increased specific gravity. Rykbost and Maxwell (1993) however, found plant population not to have an effect on the specific gravity of all the varieties they studied.

DRY MATTER CONTENT

Getachew et al. (2013) found high plant population to be associated with low dry matter content. It then rose to a peak at 30 but then fell with a further increase in plant spacing. He thought that at low plant spacing, there was a high competition for light and other important resources. This then led to a few resources being channeled to each sink. Low dry matter content at the widest plant spacing was due to the high photosynthetic rate thus a relatively high vegetative growth at the expense of the tubers. Dry matter partitioning to the tubers was less. Many other studies showed increased dry matter with decreasing plant population (Tafi et al., 2010; Burton, 1948; Vander Zaag et al., 1990; Tamiru, 2004).

CONCLUSION

Varietal and environment seemed to lead to the contradictions reported among various workers. Clearly, there is need for continued research particularly with the advent of climate change. For instance, work done under temperate contradicts that done under tropical conditions. In some instances, results varied from year to year indicating complex relationships with climate elements. Ultimately, yield is affected in a complex way by plant spacing and this is made even more complex when different varieties are evaluated. Rykbost and Maxwell (1993) showed that only one out of seven varieties showed reduced total yield at low populations while other showed consistent increased yield at high populations.

Conflict of Interest

The author(s) have not declared any conflict of interests.

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