Research Note

Future scenario of better New Zealand adapted industrial hemp varieties

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Abstract

Industrial hemp is one of the world's ancient crops conventionally cultivated for its fibre and seeds. Since recent legislative amendments in New Zealand authorised the production, sale and consumption of hemp seed food products, this revived industry has received great attention among the agricultural and industrial community. An experiment was carried out at Massey University to explore the agronomic potential of hemp cultivar 'Kompolti'. Impact of three nitrogen application rates ranging from 0 to 100 kg/ha and four planting densities ranging from 80 to 200 plants/m^2 was investigated. With a foundation knowledge from all the experiments done so far, a research project has been designed to study the genetic structure and degree of variability of selected hemp varieties and a quantitative genetic study on seed oil, protein and other significant traits will be conducted across three experimental sites in New Zealand in 2019-2020. The results would serve as a preliminary step towards hemp cultivar improvement.

Additional keywords: Industrial hemp, Kompolti, plant density, nitrogen, G×E interaction.

Background, Experimental and Discussion

With hemp food's new status as a legal food not only in New Zealand but also now in several countries around the world, the New Zealand hemp food industry is growing rapidly. With this growth, the need for new information and research regarding the growing and processing of hemp in a New Zealand context has become highly sought after. Townshend & Boleyn (2008) have revealed that hemp has the potential to be a cash crop with good returns for farmers in the Canterbury region. The benefits of growing hemp such as its natural weed suppression at high planting densities (Sandler & Gibson 2019; Swanepoel *et al*. 2018), tolerance to some pest damage and relatively low disease susceptibility (Swanepoel *et al*. 2018; McIntosh 1998)

mean that this crop could be of great benefit to New Zealand farmers using hemp in their crop rotations.

The recent change in New Zealand legislation has legalised the production and consumption of hemp seed-based foods and the growers in New Zealand are primarily interested in seed crops rather than fibre crops, although some sites evaluated dual harvest (McPartland *et al*. 2004). Hemp seed is infact known to be a complete source of plant protein. Rodriguez-Leyva & Pierce (2010) reported that hemp seed contains more digestible protein than soybean. Hemp seed contains all of the essential amino acids required by the human body and is rich in healthy fatty acids. Hemp seed is considered to be perfectly balanced in regards to the ratio (3:1) of two polyunsaturated fatty acids essential for human nutrition, linoleic and linolenic acids (Anwar *et al*. 2006) and according to Erasmus (1993), only *Cannabis* seeds contain these two fatty acids in such an ideal ratio. Callaway (2004) stated that hemp seed is technically a nut and contains 30% oil, 25% protein, a lot of dietary fibre, vitamins and minerals.

Eager to provide research to catalyse the growth of this potential new industry, Massey University has set out to understand the optimal conditions for growing hemp in the Manawatu region. Impact of different nitrogen application rates and plant densities on the performance of the industrial hemp cultivar 'Kompolti' grown in the Manawatu region was investigated during the 2018/2019 season at Massey University's plant growth unit, Palmerston North.

The silt loam soil was tilled finely with two passes with a disk before the hemp seed was sown via a direct drill. Soil nutrient tests were conducted prior to the addition of fertiliser and the average of potentially available nitrogen was 88 kg/ha.

Cultivar 'Kompolti' which is a fibre/dual purpose type, was sown at 20 cm row spacing at four planting densities, aiming for 80, 120, 160 and 200 plants/m^2.

Nitrogen fertiliser range was from 0 to 100 kg/ha. One third of the crop received 50 kg/ha of N, another third received 100 kg/ha and the final third received no additional nitrogen. This nitrogen fertiliser was applied after 8 weeks of plant growth in the form of 'Ballance sustain' fertiliser.

The crop received irrigation immediately after the fertiliser was applied. This treatment was repeated four times at the four plant densities with the three nitrogen fertilisation rates, creating 48 individual trial plots. During its life, the crop received irrigation via a "travelling gun" irrigator twice a week.

Figure 1 shows a Kompolti plant at 80 cm height.

Plants within an area of 1 m^2 of each plot were harvested. Ten random plants were selected from this sample and the above ground fresh biomass was recorded from the bundle (as shown as in Figure 2), along with average height of the plants, fresh and dry weights of seed head, fresh and air-dried stem weights.

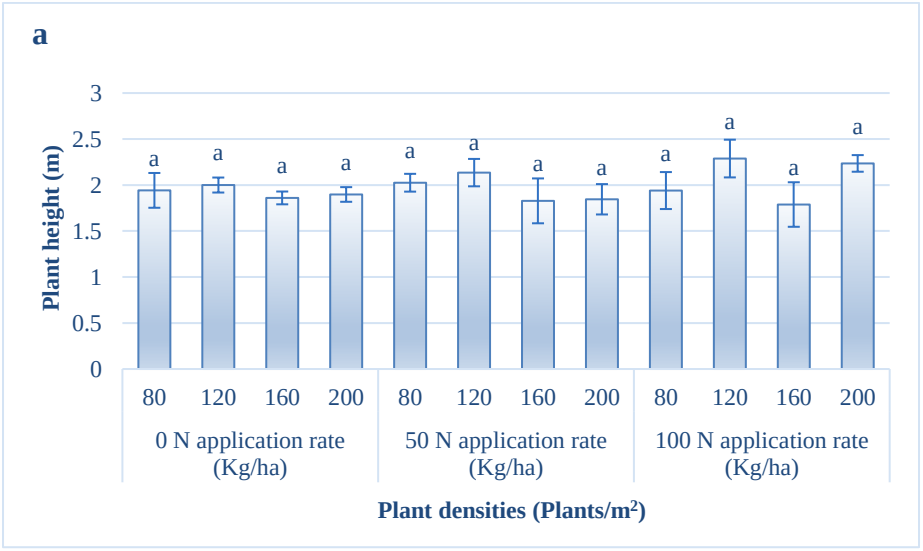
Data collected were statistically analysed using SAS 9.4 version statistical software package and mean comparison was performed within treatments using Duncan's Multiple Range test at 5% significant level. Even though fresh and dry weights of the seed head were recorded, seed yield was not assessed since the bird damage was significant. Extremely higher losses from the birds were observed as hemp seeds are palatable to birds and the birds were not

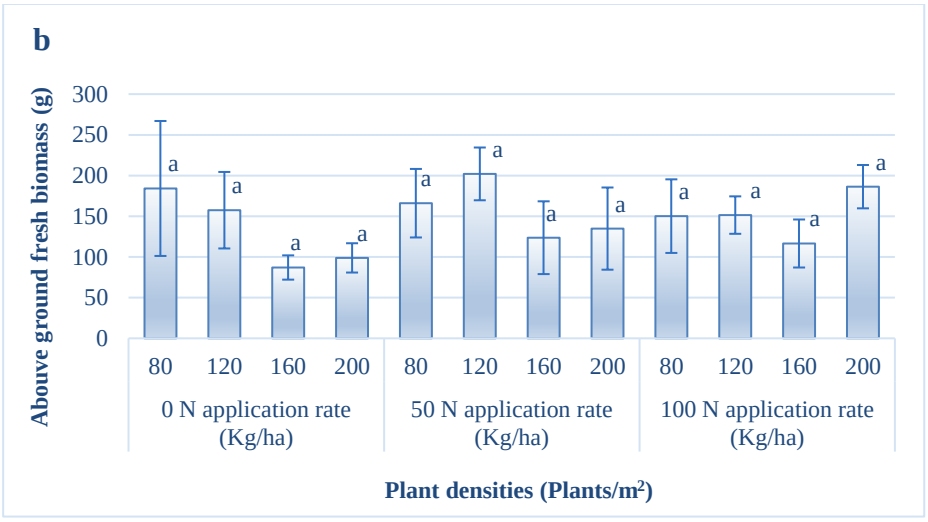
controlled with repellents or bird netting during this experiment. Initial analysis could not confirm a significant fertiliser and plant density effect on all measured parameters. Therefore, follow up experiments would need to be carried out and the trial will be repeated more precisely over multiple seasons.

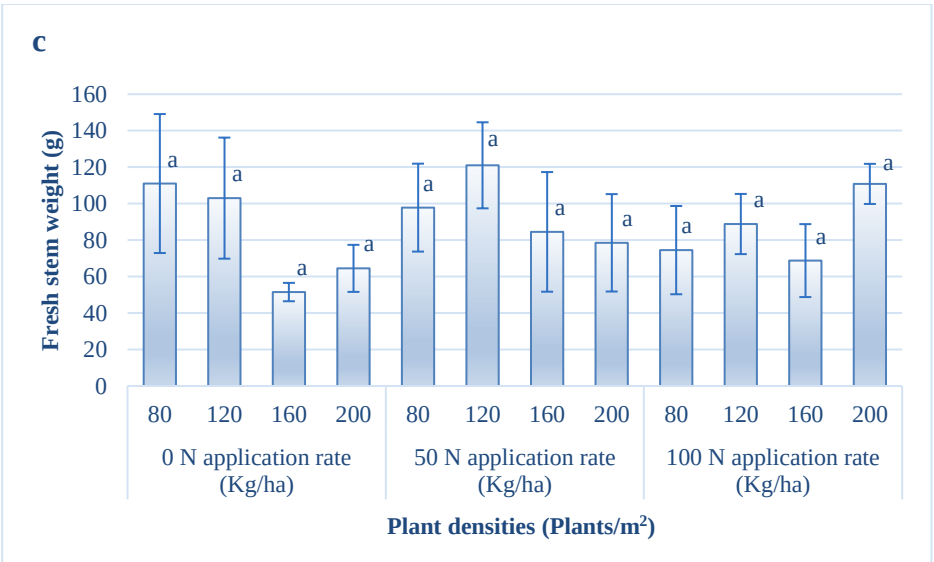
Figure 1: Kompolti plant at 80 cm height.

Figure 2: Weighing the fresh weight of ten random plants.

No significant differences were observed on the effect of different nitrogen application rates and plant densities on plant height, above ground fresh biomass, fresh individual stem weight and air-dried individual stem weight. According to the initial soil analysis result, the soil in trial site was high in potentially available nitrogen, in consequence response to nitrogen was limited (Figure 3). This result confirms findings of previous research (Prade *et al*., 2011; Struik *et al*., 2000) indicating negligible response of hemp to nitrogen fertiliser applications in soil rich in nitrogen. The results on effect of treatments on stem yield were found to be in agreement with previous studies (Amaducci *et al*. 2008a; 2002a). In addition, these observations are in accordance with Struik *et al*. 2000 who reported that increasing planting density from 30 plants/m^2 to 240 plants/m^2 had limited effect on stem yield. In line with previous study (Swanepoel *et al*., 2018), planting density did not have a significant impact on the plant height and above ground fresh biomass ($P>0.05$). Nitrogen application rates and plant densities hardly interacted in this experiment. The results illustrated in figures (Figure 3) does not suggest a pattern of gradual change in the variables. This might be due to the influence of genetic diversity observed within the cultivar 'Kompolti' and/or the interaction effect among the genetic background of the cultivar, different nitrogen application rates and plant densities.


a
Plant height (m)
3
2.5
2
1.5
1
0.5
0
a a a a a a a a a a a a
80 120 160 200 80 120 160 200 80 120 160 200
0 N application rate (Kg/ha)
50 N application rate (Kg/ha)
100 N application rate (Kg/ha)
Plant densities (Plants/m²)


b
Abouve ground fresh biomass (g)
300
250
200
150
100
50
0
a a a a a a a a a a a a
80 120 160 200 80 120 160 200 80 120 160 200
0 N application rate (Kg/ha)
50 N application rate (Kg/ha)
100 N application rate (Kg/ha)
Plant densities (Plants/m²)


c
Fresh stem weight (g)
160
140
120
100
80
60
40
20
0
a a a a a a a a a a a a
80 120 160 200 80 120 160 200 80 120 160 200
0 N application rate (Kg/ha)
50 N application rate (Kg/ha)
100 N application rate (Kg/ha)
Plant densities (Plants/m²)

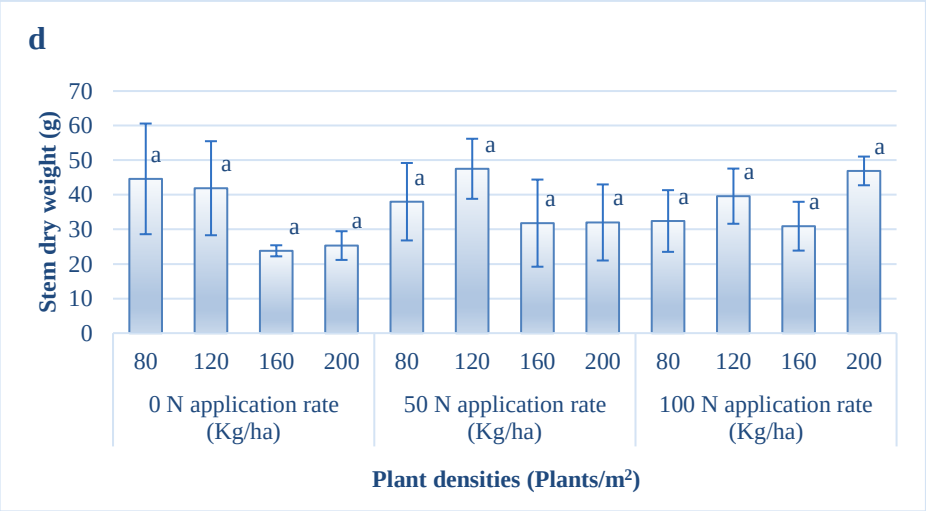


Figure 3: Effect of different nitrogen application rates and plant densities on plant height (a), average above ground fresh biomass (b), average fresh individual stem weight (c) and average air-dried individual stem weight (d) for plant growth unit, Massey University, Palmerston North site in 2018/2019 season. The bars represent the Standard Error (±SE) and mean values in the columns having same letter within treatment group are not significantly different at 5% level of significance by Duncan's Multiple Range Test.

Based on all initial experiments that have been done so far, a research project has been designed at Massey University in collaboration with New Zealand Hemp Industries Association, Ngāti Kahungunu ki Tāmaki nui-a-Rua and Midlands Seed Ltd. as a foremost initial step towards better New Zealand adapted hemp varieties, driving a positive change in New Zealand hemp industry.

This new research project has been designed with an intention of providing novel information for the establishment of efficient cultivar development programmes for hemp in New Zealand. Six cultivars grown for seed purpose will be used in this experiment. Field trials will be carried out in three contrasting locations; Dannevirke, Palmerston North and Hastings in 2019/2020 season. Hastings is a region on the east coast, to the east of the Central Plateau and the rain shadow of the Kaweka Ranges, which is generally drier and warmer compared to other two experimental sites. Dannevirke is on the Manawatu-Wanganui region and Palmerston North is in the Eastern-Manawatu plains. A quantitative genetic study on significant traits of selected hemp cultivars will be conducted across the selected experimental sites to explore the effects of genotype by environment interaction on hemp seed production. This experiment will also explore the superior performers for broad and specific adaptation in North Island region. The genetic structure and genetic variability of selected New Zealand approved hemp cultivars will be analysed using microsatellite markers. Plant morphology and seed quality traits of selected hemp cultivars that have yet to be studied in-depth will be investigated in this proposed study.

Beyond the excitement over this new industry in New Zealand, critical gaps in

research and development of this crop need to be addressed under New Zealand conditions. The output of this unique research work will act as an excellent opportunity to the plant breeders to improve the hemp cultivars and provide efficient information for the growers and seed companies about the cultivars suitable for seed production in different regions across New Zealand. This research project seeks to bridge current knowledge gaps and enable New Zealand growers to maximize the agronomic and economic potential of this unique crop.

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