Field Crops Research 219 (2018) 229–241

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

Effects of nitrogen and phosphorus on the regulation of nonstructural carbohydrate accumulation, translocation and the yield formation of oilseed flax

Bin Yan[a,b], Bing Wu[a,b], Yuhong Gao[a,b,*], Jianmin Wu[a,b,*], Junyi Niu[a,b], Yaping Xie[c], Zhengjun Cui[a,b], Zhongkai Zhang[a,b]

[a] Gansu Provincial Key Laboratory of Aridland Crop Science, Lanzhou 730070, China
[b] College of Agronomy, Gansu Agricultural University, Lanzhou 730070, China
[c] Crop Research Institute, Gansu Academy of Agricultural Sciences, Lanzhou 730070, China

ARTICLE INFO

Keywords:
Nitrogen
Phosphorus
Soluble sugar
Starch
Accumulation
Translocation

ABSTRACT

Nutrients can significantly affect nonstructural carbohydrates (NSC) of crops. This field experiment was conducted to reveal how nitrogen (N) and phosphorus (P) regulated NSC accumulation, translocation as well as the seed yield formation of oilseed flax. The treatments were as follows: (1) application of 0 kg N ha^{-1} and 0 kg P ha^{-1} ($N_{(0)}P_{(0)}$), (2) application of 75 kg N ha^{-1} and 0 kg P ha^{-1} ($N_{(75)}P_{(0)}$), (3) application of 150 kg N ha^{-1} and 0 kg P ha^{-1} ($N_{(150)}P_{(0)}$), (4) application of 0 kg N ha^{-1} and 75 kg P ha^{-1} ($N_{(0)}P_{(75)}$), (5) application of 75 kg N ha^{-1} and 75 kg P ha^{-1} ($N_{(75)}P_{(75)}$), and (6) application of 150 kg N ha^{-1} and 75 kg P ha^{-1} ($N_{(150)}P_{(75)}$). Results showed that application of N decreased the concentration and content of leaves soluble sugar (SS), and increased stems SS and starch (ST) concentration and content at pre-anthesis of oilseed flax, compared to no application of N. Application of P increased the SS concentration in leaves, stems, and seeds at all growth stages, and decreased ST concentration in leaves, seeds and stems at post-anthesis, compared to no P application. Mixed application of N and P significantly improved leaves and stems SS concentration at post-anthesis, promoted more leaves and stems NSC translocation to seeds, thus seed numbers (SN) of per capsule and effective capsules (EC) significantly increased and no-effective capsules (NEC) obviously decreased, compared to only application of N or P. Meanwhile, the average seed yields were improved 14.3%–42.6% than that of only application of N or P. We also found that the SN of per capsule had significantly positive correlation with the leaves SS concentration at post-anthesis, and it had highly positive correlation with the buds and flowers SS concentration at budding and anthesis stages, respectively. The NEC had largely positive correlation with the stems ST concentration at post-anthesis. Our results suggested that N with P mixed application is an effective way for oilseed flax production in semiarid areas by increasing the SN, EC and decreasing the NEC by regulating the leaves and stems NSC at budding, anthesis and post-anthesis, and improving oilseed flax production.

1. Introduction

Plants are primarily composed of carbohydrates, lipids, proteins, vitamins, and minerals. Therefore, Carbohydrates are necessary for plant maintenance and development, and serve as the substrates for many compounds needed for crop growth. They are the most abundant organic molecules in nature (Raven et al., 2005). The limited understanding of the mechanisms that govern the partitioning of carbon resources (carbohydrates) between different plant tissues is considered to be the main factor restricting the understanding of whole plant growth (Cannell and Dewar, 1994). There are many target traits that relate directly to whole-plant carbohydrate partitioning (Fischer and Edmeades, 2010). Therefore, it is critical for us to determine how crops assimilate, transport, and store carbohydrates because these processes underpin all aspects of crop productivity.

The assimilates used for grain filling in cereals are supplied concurrently from two sources: (i) current assimilates in photosynthetic leaves during the grain-filling stage and (ii) reserves in vegetative tissues before anthesis (Samonte et al., 2001). Nonstructural carbohydrate (NSC) is mainly composed of SS sugars and ST, and they are reserves in plant tissues, including those responsible for grain filling (Ishimaru et al., 2004). Carbohydrate partitioning plays an important role in plant

* Corresponding authors at: Gansu Provincial Key Laboratory of Aridland Crop Science, Lanzhou 730070, China.
E-mail addresses: gaoyh@gsau.edu.cn (Y. Gao), wujm@gsau.edu.cn (J. Wu).

https://doi.org/10.1016/j.fcr.2018.01.032
Received 2 March 2017; Received in revised form 31 December 2017; Accepted 28 January 2018
Available online 20 February 2018
0378-4290/© 2018 Elsevier B.V. All rights reserved.

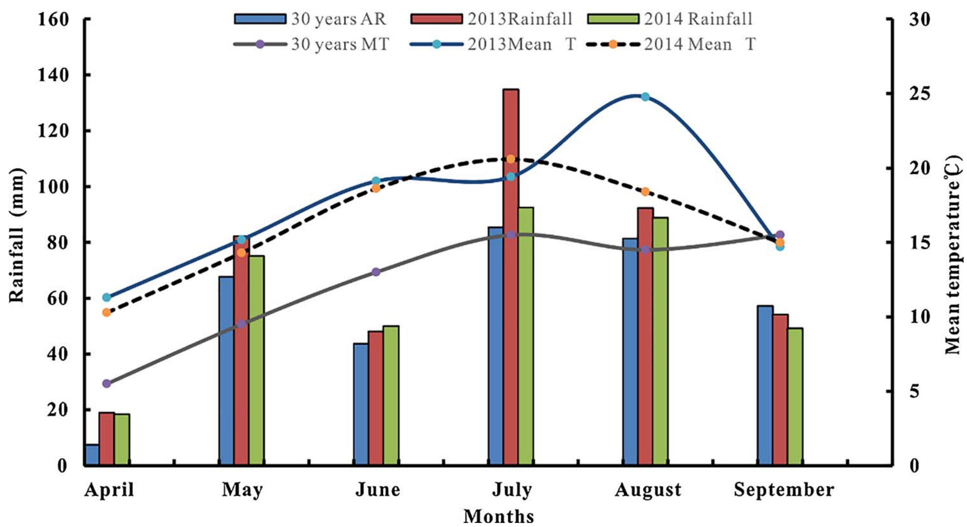

Fig. 1. Monthly mean air temperatures and accumulated rainfall in 2013 and 2014 vs. the 30-year average (1980–2010) in Dingxi, China.

Table 1
Effects of nitrogen (N), phosphorus (P), year (Y), and their interactions on the soluble sugar (SS), starch (ST) of oilseed flax.

Organs	Items	Seedling		Budding		Anthesis		Kernel		Maturity	
		SS	ST	SS	ST	SS	ST	SS	ST	SS	ST
Leaves NSC Concentration	N	ns†	**	**	**	ns	**	**	**	ns	ns
	P	ns	**	ns	ns	ns	ns	ns	ns	ns	ns
	N × P	*	**	**	**	ns	**	ns	ns	ns	ns
	Y	**	**	**	**	**	**	**	**	**	**
	Y × N	**	ns	**	ns	**	ns	ns	**	ns	ns
	Y × P	ns	**	*	**	ns	**	ns	ns	ns	ns
	Y × N × P	**	**	**	ns	ns	ns	ns	ns	ns	**
Stems NSC Concentration	N	**	ns	ns	ns	**	ns	ns	ns	*	ns
	P	ns	**	ns	**	**	**	ns	ns	ns	ns
	N × P	ns	ns	ns	ns	**	**	ns	ns	ns	ns
	Y	**	**	**	**	**	**	**	**	**	**
	Y × N	ns	**	**	**	**	**	ns	**	ns	ns
	Y × P	ns	ns	ns	ns	**	ns	ns	ns	**	**
	Y × N × P	ns	ns	ns	ns	**	ns	ns	ns	ns	**
Leaves NSC Content	N	ns	ns	**	ns	ns	ns	**	**	ns	ns
	P	ns	ns	**	**	**	ns	**	ns	**	ns
	N × P	ns	ns	**	**	ns	**	ns	ns	ns	ns
	Y	**	**	**	**	**	**	**	**	**	**
	Y × N	ns	ns	**	ns	ns	ns	**	ns	ns	ns
	Y × P	ns	ns	ns	**	**	ns	ns	**	ns	ns
	Y × N × P	**	ns	**	**	ns	**	ns	ns	ns	ns
Stems NSC Content	N	ns	ns	ns	ns	**	ns	ns	ns	ns	ns
	P	ns	ns	ns	ns	**	ns	ns	ns	**	ns
	N × P	ns	ns	ns	ns	**	**	ns	ns	ns	**
	Y	**	**	**	**	**	**	**	**	**	**
	Y × N	ns	ns	**	ns	**	ns	ns	ns	ns	ns
	Y × P	ns	ns	ns	ns	*	ns	ns	ns	**	ns
	Y × N × P	ns	ns	**	ns	**	ns	ns	ns	ns	**

* Significant difference within treatments at the 0.05 level.
** Significant difference within treatments at the 0.01 level.
† ns, no significant difference within treatments at the 0.05 level.

productivity and can vary with specific life forms. For example, rice genotypes with low grain weight often have high stems NSC concentration at harvest (Samonte et al., 2001). The NSC accumulation in the vegetative tissues before anthesis contribute 24% to 27% to the grain yield in rice (Yoshida and Ahn, 1968). Similar ranges of the contributions of stems NSC to grain yield have been determined in barley (*Hordeum vulgare* L.), i.e., from 11% to 45%, and wheat (*Triticum aestivum* L.), i.e., from 13% to 27%, depending on the location and year (Bingham et al., 2007).

Nitrogen is a crucial factor to regulate carbon balance of plant (Guo et al., 2016). Heavy use of N fertilizer delay senescence of crops, which has an opposite effect on the translocation of stems NSC to the grain, thus decreasing the contribution to grain-filling (Hirano et al., 2005; Fu et al., 2011; Pan et al., 2011). Heavy use of N results in much NSC left in the straw and leads to low harvest index (Yang et al., 2001). High N also resulted in larger biomass and tiller number, decreased sink strength of wheat and this process associated with carbon remobilization (Fu et al., 2011) and ST accumulation (Hirano et al., 2005). A negative relationship between N and carbohydrate concentrations in reserve organs of fruit trees, because of N assimilation consumes carbohydrates for carbon skeletons and energy (Cheng and Fuchigami, 2002; Xia and Cheng, 2004). These reports indicated that nitrogen play a critical role

Download English Version:

https://daneshyari.com/en/article/8879328

Download Persian Version:

https://daneshyari.com/article/8879328

Daneshyari.com