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ORIGINAL ARTICLE

Effect of Cover Crop Mixtures and Nitrogen Contribution on Sustainable Growth and Yield of Corn

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ABSTRACT
Organic cropping systems that utilize winter grown brassica–legume cover crop mixtures can increase plant available nitrogen (N) to a subsequent cash crop, but the rate of N release is uncertain due to variations in residue composition and environmental conditions. A study was conducted to evaluate N availability from Perko (Perko PVH)– vetch(Vicia villosa L.)cover crop mixtures and to measure the response of Sustainability grown and Yield of corn(Zea mays L.) to N provided by cover crop mixtures. Nitrogen availability from pure Perko, pure vetch, and Perko –vetch mixtures was estimated using laboratory incubation with controlled temperature and soil moisture. corn N response was determined in a 1-year field experiment in Islamic Azad University of Shahre-Rey Tehran-Iran with two cover crop treatments as sub plots (100%vetch, 100% perko, 50%vetch 50%perko, 75%vetch 25%perko, 25%vetch75%perko and no cover) and four feather meal N rates as main plots (0, recommended amount of nitrogen [300kg/h], 50% less than of recommended amount of nitrogenha^{-1}). Pure vetch and a 75% perko –25% vetch biomass mixture ($P_{75}V_{25}$) released similar amounts of N over 70days in the laboratory incubation. But, the initial release of N from the ($P_{75}V_{25}$) treatment was nearly 70% lower, which may result in N release that is better timed with crop uptake. Cover crops in the field were dominated by perko and contained 34–76kgha^{-1} total N with C:N ranging from 18 to 27. Although time of planting and management of cover crop quality improved N uptake in corn, cover crops provided only supplemental plant available N in this system.
Key words: *cover crops, growing degree days, vetch, nitrogen,Perko, corn yield*

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INTRODUCTION

The multifunctional profile of intercropping allows it to play many other roles in the agroecosystem, such as resilience to perturbations, greater competition against weeds, improved product quality and reduced the negative impact of arable crops on the environment [1-3].Cover crops can provide a sustainable, on-farm source of N for organic farming systems, reducing the need for off farm in puts. Crop yields can be maintained by replacing or supplementing N fertilizer with residue N from legume cover crops that fix N, brassica cover crops that scavenge residual available N, or a combination of brassica–legume cover crop residues [4].Effective cover crop N contribution depends on sufficient N accumulation in the cover crop biomass and timely mineralization of the accumulated N, the degree of synchrony between N supply from cover crop residue and crop N uptake can influence the efficiency of crop N use [5]. This depends on cover crop composition, environmental conditions, the timing of field events and the type of crop grown [6]. Mixing cover crops with legumes can enhance N cycling because the combined cover crops often have larger biomass and total N content than legumes [7]. Perko is a standard winter cover crop in many regions in Europe, because it establishes quickly and thrives in cool conditions [8]. Vetch has been shown to be a hardy winter legume, but it prefers warm soil temperatures and therefore establishes more slowly in cool conditions [9].There is evidence that cover crops grown in bicultural have wider range of tolerance to adverse environmental conditions than grown in monoculture [10]. In addition, perko may act as a nurse crop to the vetch, as has been observed in other experiments [11]. Brassica–legume mixtures have lower C:N ratios and more plant available N than cereals grown in monoculture [12].

Management practices that affect N content and release dynamics from plant residue are changes in residue quality due to planting date, enhanced mineralization due to a combination of cover crops and fertilizer, and a reduction in residue size [13]. The biological processes involved in soil N transformations are temperature-dependent [14]. The advantage of using growing degree days to account for the effect of temperature on N mineralization is that it allows for comparison between laboratory and field trials [15]. Cover crops influence subsequent crop yield primarily via their effect on N availability [16]. Crop yields can be maintained by replacing or supplementing N fertilizer applications with winter legume or brassica–legume cover crop residues [7]. Reported N fertilizer replacement values for winter-grown cover crops to subsequent cash crops vary greatly. Several studies examine corn performance after legume and mixed cereal–legume cover crops because of its marked response to N additions. Other researchers have reported yields equivalent to N-fertilizer treatments when grown in rotation with vetch [17]. In this study, field experiments were conducted to improve our understanding of the N contribution of perko-vetch cover crop mixtures in Sustainable farming systems. This experiment was designed to determine whether perko- vetch cover crop quality (C:N ratio, fiber fractions) could be managed to increase and time N mineralization from cover crops with nitrogen uptake in Sustainable grown and yield corn with and without feather meal.

MATERIALS AND METHODS

This field experiment was conducted in research farm of Islamic Azad University of Shahre-Rey Tehran-Iran. The study was arranged in a randomized complete block split-plot design. Each of the four blocks contained randomized replicates of each treatment. Main plot treatments were the N-fertilizer rates applied to corn (0, recommended amount of nitrogen [300kg/h], 50% less than of recommended amount of nitrogen). Also sub plot treatments were different rate of cover crops planting (100%vetch, 100% perko, 50%vetch 50%perko, 75%vetch 25%perko, 25%vetch75%perko and no cover). Main plots measured 34×4m, sub plots measured 4.5×4m.Soil samples taken to a 30 cm depth prior to cover crop planting at the start of the field experiment, indicated that phosphorus, potassium and pH levels were uniform across the field site. Seeding rate for the perko–vetch mixture was 112 and 30 kg ha^{-1} Feather meal was hand-broadcast across each plot at the appropriate rate prior to planting corn. Perko and vetch were drilled together in the fall and chopped in the spring using a flail mower set 5cm above the soil surface. Cover crops were incorporated using a rotary spader, a cultivator that uses rotary motion to turn spade-shaped blades to invert the top 10cm of the soil. corn was seeded by hand on 0.75m between-row and 0.25m in row spacing at the rate of 90,100 seeds ha−1. Each plot was 6 rows wide. After harvest, corn stover was flail mowed and incorporated with a rotary spader, and the plots were prepared for cover crops for the next season. Cover crops above-ground biomass was measured by harvesting a 0.25m^2 quadrats in each plot. The harvested forage from each plot was weighed wet, and a subsample (approximately 500 g) was collected and oven dried at 55°C to determine dry matter. The remaining residue was returned to the plots.

RESULTS AND DISCUSSION

Effect of residue C:N on N release:

Residue C:N ratio was negatively correlated with net N release from perko, vetch and mixtures of perko–vetch cover crops for the first 30 days of the 120-day incubation (Pearson correlation coefficients ranged from −0.83 to−0.93), which is consistent with other studies [21]. The C:N ratio of residues was a better predictor than fiber characteristics. In this study, NDF was negatively, but more weakly correlated to net N mineralization through the first 30days of the incubation. Pearson correlation coefficients between NDF and N mineralization ranged from −0.64 and −0.83. Others have reported that the NDF fraction and hemicellulose, a component of the NDF fraction, are sometimes weakly related with N release from plant residues, and neither are particularly good predictors of N release [18]. Our data indicate that N release patterns from cover crop residues with narrow C:N ratios can be predicted based on the C:N ratio and correlated using growing degree days. Other researchers have used similar predictors [19].

Cover crop biomass, plant composition and quality:

Planting date and year had a significant effect on cover crop biomass accumulation, species composition, and C:N ratio (Table 1) perko and vetch was killed at the flowering stage, which reduced the potential for high C:N ratios. Cool conditions in during the establishment and spring growth phases may limit vetch production, resulting in lower N uptake. Cover crop stands were dominated by perko, which accounted for 90% of the total biomass. Lower tissue N concentrations and higher C:N ratios can be accounted for by the low amount of hairy vetch biomass (10%) present in those stands (Table 1).

Corn N uptake, dry matter and yield production:

Cover crop N contribution to the corn was relatively small compared with soil N and feather meal N. Different ratio cover crop effects on corn above-ground biomass, yield and N uptake were small and not statistically significant (data not shown; P=0.05). Total N accumulated in the above-ground biomass cover crop was 95–105kgha^{-1} with ANR in the corn estimated as 25–45kgha^{-1}.Feather meal effects were significant ($P<0.05$) for all three measurements (Table 3), with an ear yield plateau occurring at the 120kgha^{-1} rate. The only N effect of cover crop was apparent in the post-harvest soil nitrate samples for cover crop (Table 2), and then only at the highest feather meal rate, which was in excess of the peak rate for ear yield. There were no significant interactions between cover crop and feather meal treatments. The lack of significant response to cover crops was likely a combination of low N supply from the cover crops (Table 1) and high background available N in the soil. Soil background N was 77–81 kgNha^{-1} as measured by N uptake into corn in the unfertilized, no-cover crop control plots. These measurements are consistent with field data from previous experiments with similar soil and environmental conditions [20].

Nitrogen supply from cover crops comparison:

Results showed that the composition of the cover crop mixtures had a large effect on the initial mineralizationrate, with pure vetch (C:N=15) releasing N at three times the rate of the P75V25 mixture (C:N=19). The slower rate of N release from the perko–vetch mixtures may result in N release that is better timed with crop N uptake, increasing N uptake efficiency. In the field, cover crop N contribution to corn was small compared with soil and feather meal N because of low cover crop N accumulation and the high proportion of perko in cover crop mixtures. The composition was similar to a mineralization rate of 50% over a 60-day period that was measured in the P75V25 treatment. This treatment provided an estimated 35kgha^{-1} of available cover crop N. N Content was 79kgha^{-1} with a composition similar to pure perko (60-day mineralization rate of 46%), providing an estimated 36kgha^{-1} available N. Therefore, the N contribution of cover crops was insufficient relative to the seasonal N requirement of corn.

CONCLUSIONS

The perko–vetch blends grown in this study had modest biomass yields, similar to other regions with cool spring and fall climates, but contained less vetch and had lower N accumulation than reported from other researcher. Relatively cool temperatures during the critical times of establishment in the fall and biomass production likely favored perko over the vetch. We did not observe immobilization of N in the pure perko in field plots containing perko and perko–vetch mixtures, either in the field.This may be because the perko did not mature beyond the flower stage at the time of termination. The results showed that the composition of the cover crop blends had an effect on the initial mineralization rate, with pure vetch releasing N at three times the rate of a 75% perko–25% vetch (P75V25) blends. The slower rateof N release from the perko–vetch mixtures may result in N release that is better timed with crop N uptake, increasing N uptake efficiency. Our study indicates that there is the potential to manage perko, or predominantly perko, cover crop mixtures for improved soil quality without creating conditions that result in N immobilization in the field during the period of crop N uptake. While brassica–legume cover crop mixtures have been shown to be a reliable source of N to cash crops in other parts in Iran. Long-term additions of cover crop biomass contribute to soil organic N, but cover crops were an insufficient source of seasonal plant available N in our system. Future research should address short-term increases in EC that influence the rates of microbial processes controlling mineralization and gaseous losses during incorporation of cover crop amendments under field and laboratory conditions.

Table 1. Cover crop (P=perko, V=vetch) biomass yield, total Nuptake, tissue N concentration, C:N ratio, and dry matter composition for residues sampled from the field

Cover crop treatment	Biomass (Mgha^{-1})	N uptake (kgha^{-1})	N concentration (gkg^{-1})	C:N Ratio	Dry matter composition	
					perko (%)	Vetch (%)
Pure Perko	3.56c	54c	23a	15a	98a	31a
Pure vetch	2.90d	48d	21.6a	19a	87b	12b
$P_{75}V_{25}$	4.98a	79a	22.32a	21a	89a	10c
$P_{25}V_{75}$	4.11b	60b	23.10a	25b	82a	8d
$P_{50}V_{50}$	4.21ab	69ab	22.9a	23a	88a	7e

An ANOVA was run in SAS Proc Mixed. Values within a column and year followed by the same letter are not significantly different at P≤0.05.

Table 2. The effect of cover crop and feather meal rate on soil nitrate ($NO3^-$)–N concentration measured at pre-sidedress nitrate test (PSNT) time, and post-harvest. Zero-feather meal plots only were sampled at PSNT.

Cover crop treatment	Significance	Feather meal available N rate (kgha^{-1})				
		planting	PSNT	recommended	50%less than	0
					Soil ($NO3^-$)-N, mgkg^{-1}	
Pure Perko	*	9a	14c	2b	3b	4c
Pure vetch		8a	15b	2b	3b	6b
$P_{75}V_{25}$		8a	19a	4a	6a	9a
$P_{25}V_{75}$		8a	18a	3a	5a	8a
$P_{50}V_{50}$	NS	7a	17a	3a	5a	8a

ANOVA was run in SAS PROC MIXED. Values followed by the same letter within each test date and year are not significantly different at P≤0.05. *Indicates significance at P≤0.05. NS=not significant.

Table 3. corn yield and above-ground dry matter as affected by feather meal for averaged over all cover crop treatments.

Cover crop treatment	Feather meal available N (kg ha−1)	Grain yield (Mgha−1)	Aboveground dry matter (Mgha−1)	N uptake (kg ha−1)
	recommended	11001a	15007a	146b
Pure Perko	50%less than	10133ab	15000ab	142b
	0	10000b	14112c	131c
	recommended	11005a	14998b	137bc
Pure vetch	50%less than	10123ab	14442ab	132bc
	0	10121b	13957c	121d
	recommended	11222a	15467a	156a
$P_{75}V_{25}$	50%less than	11143a	15432a	154a
	0	10911b	14987b	143b
	recommended	10111ab	15332a	151a
$P_{25}V_{75}$	50%less than	10022ab	15223a	150a
	0	9911c	14786b	140b
	recommended	11000a	15116a	151a
$P_{50}V_{50}$	50%less than	10232ab	15006a	152a
	0	9811c	14345b	141b
	recommended	9455c	14001c	136c
No cover crops	50%less than	9234cd	14000cd	133c
	0	9111d	13987d	122d

ANOVA was run in SAS PROC MIXED. Values followed by the same letter within a year and column are not significantly different from each other at P≤0.05.

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